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Nidhu Bhushan Memorial Lecture

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Background of

Nidhu Bhushan Memorial Lecture

This lecture was instituted in 1966 by the illustrious metallurgist-philosopher Late Prof Guru Prasad Chatterjee in memory of his father Late Nidhu Bhushan Chatterjee. In Nidhu Bhushan, we find a man who, without being an engineer in the conventional sense, had the urge to serve mankind through his knowledge of science coupled with great inspiration derived from his knowledge of metaphysics. Although he got admission to Bengal Engineering College through a stiff competitive examination, he could not complete his studies on pecuniary ground. He wanted to be an engineer since he believed that one with love for scientific studies should alone become an engineer who has better opportunities to prepare himself for better service to his fellow beings.

With strong determination, Nidhu Bhushan, a science graduate, could raise himself to the position of an Inspecting Accountant in the Finance Division of Central PWD. He continued to serve the society never caring for name or fame. Nidhu Bhushan was a firm believer in the fact that only fundamental discipline in the life can help man to set around from within to face life without fear or frustration.

Nidhu Bhushan Memorial Lectures

delivered during Annual Conventions and Indian Engineering Congresses

The First Nidhu Bhushan Memorial Lecture was delivered during the Forty-seventh Annual Convention, Bombay, February 27, 1967

Technology — A World-Unifying Force

Professor N S Govinda Rao

President Gen. Vohra, Dr. Chatterji, Fellow Members of the Institution, Ladies and Gentlemen:

Let me at the outset thank the President and the Council of the Institution of Engineers (India) for having given me this opportunity to share my thoughts on this important subject of the part played by technology in unifying the world.

Before I start with my lecture, I must express my gratitude to my friend Dr. G. P. Chatterji for having instituted the "Nidhu Bhushan Memorial Lecture" to commemorate the name of his departed revered father Nidhu Bhushan Chatterji. It is unfortunate I had not the privilege of knowing his father. Knowing intimately as I do, Dr. Chatterji, and if he is only a chip of the old block I can well imagine how the huge solid block could have been. Dr. Chatterji is one of the few who have successfully practised the tenets enunciated in the Bhagavat Gita. He is a true Karma Yogi, true to the definition given for this path:

योगस्थः कुरु कर्माणि सङ्गं त्यक्त्वा धनञ्जय ।
सिद्धयसिद्धयोः समो भूत्वा समत्वं योग उच्यते ।

(Ch II Sl 46)

(Translation - Being steadfast in Yoga, O Dhananjaya, perform actions, abandoning attachment, remaining unconcerned as regards success and failure. This evenness of mind (in regard to success and failure) is known as Yoga). A follower of this Karma Yoga has no personal motive for any action. His action without motive becomes colourless, losing its character of virtue and vice. As stated in the next sloka of the same chapter, it is the nature of all work to produce bondage, But Karma Yoga is the very embodiment of it dexterity of work".

योगः कर्मसु कौशलम्

Any work dope by a Karma Yogi automatically becomes the very means by which freedom from all bondage is achieved. It is like using a thorn to remove a thorn. It is in this spirit of a Karma Yogi, Dr. Chatterji has made this endowment. The same Gita, (Chap. 17, sloka 20) describes the various types of gifts. It says "to give is right- gift given with this idea, to one who does no service in return, in a fit place and to a worthy person, that gift is held to be Satt-Vika". This gift is something unique, in as much as it can be considered as an ever lasting tribute to this great Institution of ours and that by a man like Dr. Chatterji who stands great, head and shoulders above a1l of us. Sir, we are grateful to you for this gift. In remembering you the donor, I assure you, we will not forget to pay our tribute to your worthy father of a worthy son. I was told that the subject to be chosen for this lecture must be related to Science, Philosophy and Spiritualism. I hope the subject of today's lecture, Technology- A World-Unifying Force, meets this requirement.

It has been truly said that all human activity tems from a desire for happiness. This quest for happiness has gone on ever since man came into existence. Many have given up the attempt as hopeless. It was, I think, Lord Buddha who said to be born is to be miserable. At the time of birth, the yet to be born babe depends for its very life and future happiness on the midwife. During the first five years, the child has to depend entirely for its happiness on its mother and those that are near her. When the boy enters school, he has to submit himself to the discipline of the teacher who largely moulds his career for his future happiness. When the youth joins a profession for a living and settles down to a family life, his happiness is dependent on his boss in the profession and his partner at home. When the old infirm man retires, his happiness is dependent on the assistance he receives from his children and often on the family doctor as well. After his death, the decent burial of his body depends on the goodwill of those he has left behind. So it is, that from the time of inception of birth, to the termination of his physical existence, man has to depend for his happiness on somebody or other. The solution offered by Lord Buddha was that your actions and the motives ehind your activities should be such that they do not lead to your rebirth. As already mentioned, the same advice is also offered in the Bhagavat Gita. But then how many can follow this advice? Not one in a million.

Another solution of this problem for getting happiness has been put forth by our ancient Rishis. It has been stated that happiness is a state of mind. As long as the mind is kept free from all desires, there is nothing that can disturb the serenity of the mind. It is the mind thatis the root cause of all unhappiness. All agitations of the mind start with desires. It may be desire for more and delicious food, attractive clothing, luxurious and comfortable homes, and a thousand other necessities, to better satisfy our physical wants. Desires may arise from psychological dissatisfactions - desire to put down another because he is getting on better than us, desire to take away the wealth of another because he is richer than we are and so on. Saints live in isolated caves, up on the Himalayas, on the Vindhyas, in Danda Karanya, near burial grounds, perfectly happy with whatever they get to keep body and soul together, utterly free from all desires. This solution can only be of theoretical interest to most of us.

Other saints, to name only a few, Swami Ramakrishna, Swami Vivekananda, Swami Ramadas and others have told us that it is perfectly in order to have desires — as long as desires are not allowed to dominate your mind to cloud your power of judgement. To be in the world yet to be out of it is the path to perfection.

To be in the world is to live fully enjoying all the bounties of nature, Exploitation of these natural resources for the benefit of man is the work of the technologist. Planning the use of these resources is done by the scientist. The design and development of the products is the work of the engineer. The actual fabrication in a form to be used is the work of the technician and the craftsman. Thus technologists, who comprise of scientists, engineers and craftsmen, have promoted the well-being of man, to such an extent that today men are striving to live for ever, if only to enjoy all tbe physical pleasures.

Men, who have achieved worldly success even to an extent when they can practically get anything they want complain they are not bappy. That is because, saints tell us, such men are unable to remain mentally unaffected by such successes. They are not "out of the world" that is they cannot remain beyond the orbit of worldly influences. Many saints have demonstrated by actually living a life of detachment while quite busy in all human activities that a perfect synthesis of physical activities and mental control is quite feasible. Mabatma Gandhi, in recent times can be cited as an example.

This synthesis of activities, consummation of physical desires coupled with mental detachment need not necessarily be confined to a few persons. This unification whic is synonymous of synthesis which is the step leading to perfect happiness is a world movement. How far technology has been successful in the evolution of such a world order of universal plenty and peace is the theme of my lecture today.

There is a very large school of thought composed of persons like me (shall I say you also) who think by the attainment of objectives which for the moment they are lacking will give them perfect happiness. If he is sick, his one desire is to get well. He thinks he has only to get wen to be happy. If a man is suffering from poverty, he desires to acquire wealth so that he can be happy. If he is a subordinate in an office, his desire is to become one day an officer, so that he can acquire the power to do what he likes without being questioned and thus be happy. It is mostly by the striving of these persons who were dissatisfied with their present condition and desired to be happy by acquiring what they thought they lacked, technology has grown.

One of the earliest revolutions in technology must have been in the production of food. Man was at first dependent on the flesh of the animals, on the fish of the rivers and the seas, on the tubers and fruits of the forest. This was a precarious method of sustenance as his very existence depended on the vagaries of rainfall and other climatic conditions. Quite often he must have gone without food. It was only natural, a desire should have arisen to make himself free from such predicaments. He liked to grow and store food which he could use whenever he liked.

He began to grow crops by sowing seeds. Procurement of food was a full time occupation. He had hardly any leisure to do anything other than searching for food. From this primitive stage, we have now come to a stage, when in a country like U.S.A. only nine per cent of the population can grow enough food to feed the entire country and thus set free the remaining 91 per cent to take to other avocations. Not only that, we are now consuming greater varieties of food, rich with vitamins and high in their calorific and energy contents. We can preserve them for days, weeks, months and years in warehouses, silos and bins, in cold storages, in tins and cans, and even as tablets. Technology has advanced to such an extent that it is now possible to grow food in places where growth of any plant was considered impossible. This has lead to migration of population from one area of the world to another. People from Europe went to the Americas, Australia, Africa and to Asia to grow coffee, tea, cocoa, sugar-cane, cereals, oil seeds and many other crops. People from Africa and Asia also migrated but more often they were taken in chains to slave for their white rulers as labourers. Whatever the reasons, history records that there was a great intermingling of population. In course of time, today, people whose original home was in diverse parts of the world have not only united together in the newer continents but have learnt to coexist without kill ing one another. The force generated by the development of technology of growing, processing, storing and cooking food have unified the world to many common habits. Over ninetyfive per cent of the population eat practically the same types of food, thus indicating a certain unity in food habits. Just to quote an example, many Indian dishes and condiments can be found on the dining tables in European countries. Many European delicacies, vegetables and fruits have found their way to Indian homes. This is true not merely of India but of all countries of the world.

The progress made in the production and utilisation of clothing - which is one of the essential requirements of man has been equally remarkable. These technological advances have stemmed from the desire to be free from the effects of variations of temperature and humidity and to prevent giving cause to intemperate outbursts of lust. As a result of our advances in textile technology, there is a world unification in the materials we use for our clothingleather, wool, cotton, silk and artificial fibres. All countries import or export or do both textiles of various materials, colours, textures, finishes, stitched and unstitched. This has promoted a common desire to trade peacefully between man and man in the goods that are essential for our living.

The other primary need of man has been housing. In the dawn of history, man lived in caves, on tops of trees, and other places exposed to ravages of the sun, wind, and rain, the dangers of wild animals and reptiles. Naturally he desired security against these forces. In addition he desired security not only for himself, but also for his family, his possessions, and in some cases his community against attack from his enemies. This desire was the incentive for building houses, forts and villages enclosing groups of houses. The technology of town and country planning, and the building of structures for dwelling and other purposes has made great strides since then. The technology of village construction has lead to unifying hundreds to live together within its boundaries. There are several cities which have unified thousands and millions of people to live together peacefully within the compass of their limits. They have united to have common sources of power, water-supply, roads, transport services and the like. Technology has developed now to an extent when it is possible to construct one single multistoried building to bring hundreds of people within its roof so as to live together in amity and peace. Great strides have been made since the advent of the primitive man, in the use of materials for constructing structures - mud, bricks, stone, cement, steel, timber, paints, plastics, glass and a host of others, in the size and methods of construction and in the planning and design of different structures for different uses. Huge temples and churches bring masses of people together. Materials useful for construction are moved over long distances, sometimes from one part of the world to another. This force generated by the development of this technology has embraced in its orbit the entire world as it has been responsible to bring about a common understanding in our living in our homes, villages, cities, countries, that is in the entire world.

Next in importance to housing is the technology of water resources development. The desires to lead a healthy life, to grow more food, to harness power so as to lessen the drudgery of work, have been the main motivating forces for development of technology in this field of activity. In the past, wells, lakes and rivers were the main motivating forces to bring people together to live in villages. As technology advanced, reservoirs were built, huge canals were excavated and often gigantic pumps were installed. These activities created forces which brought together thousands and millions united in their sole purpose of exploiting these resources for development of irrigation, navigation, flood control, fisheries, drinking water supplies, sanitation and the like. Huge hydro-electric projects have been developed which have generated the motivating force for bringing large numbers of people together to develop industries. When the technology of its conversion to steam was mastered, the pace of progress towards unity of manjumped from its snail-speed to that of the mail train. It became the force to bring thousands together to work in factories, in railways, ships and other transport undertakings.

Other successes In technology were the discovery of coal, metallic ores, oil and gas below the ground and their exploitation to a million uses. A systematic technology was developed to find the various natural resources a vailable on and below the earth. Thus started the development of the earth sciences of geology, mineralogy, geophysics, botany and the like, the life sciences of biology, zoology, ecology, etc., the basic sciences like mathematics, physics, chemistry and so on, and the applied sciences like engineering and medicine with all its branches, the social sciences like economics, and sociology, and the mental sciences like psychology. There was a knowledge explosion which widened and deepened to the farthest limits of understanding almost to the boundary where the mind dissolves to exist as such. Humanity as such has yet to reach the boundary. Millions are today united in their purpose of exploiting nature for the benefit of man. Millions and millions of men have had their desires to possess many things fulfilled. The scientist, the manufacturer and the consumer have all been brought together. This impressive development in the technology of our understanding, application, and processing of the bounties of nature, specially during the present century, has accelerated our ideas of community living in peace and harmony from that of the mail train of the railways to the speed of the jet plane and the satellite. We have yet to reach the speed of light, - we are hopelessly far behind when it comes to synchronising our physical movement with the speed of thought. Our progress in this field is still in its infancy.

When walking was the only method of transporting both himself land his possessions, we can very well imagine the suffering the primitive man must have gone through, perspiring heavily under the hot sun or shivering to the bones exposed to the blast of a cold piercing wind. Maybe, he was compelled to undertake this journey to meet a near and dear one lying on his death bed about to breath his last. Maybe he had to run away from a foe out to kill him. Dear audience, I leave to your imagination, how intense, how burning could have been the desire of this primitive man for wings, for a magic carpet, for anything that could take him to his destination in an instant of time. He started training the horse, the donkey, the camel, and the bullocks. This desire for better and better, faster and faster means of movements on the roads, on the seas, up in the clouds in the air, has been the foundation for development of a technology whose progress specially in the last decade has been breathtaking. The following table taken from 'Science and the future of Mankind' by Huge Boyke (published by Uitgeverij Dr W Junk- Den Haag 1961) gives an idea of the shrinking of our planet by man's speed to travel round the globe.

Year	*Time needed*	*Means*	*Area traversed*
500,000 B.C.	a few hundred thousand years	on foot over land and ice-bergs	—
20,000 B.C.	a few thousand years	on foot and canoe	a small valley, foreshore of a lake
3,000 B.C.	a few hundred years	small sails, paddles, relays of runners	small parts of a continent.
500 B.C.	a few tens of years	big sail ships with paddles, horses, relays of runners, carts ; camels and riders	big parts of continent with coastal colonies
1,500 A.D.	a few years	big sailing ships with *compass*	big parts of continents with trans-oceanic colonies
1,900 A.D.	a few months	steam boat, railway (Suez Canal, Panama Canal)	–do–
1925 A.D.	a few weeks	Steam boat, railways, automobiles, and airplanes	Whole continents
1950 A.D.	a few days	Steam and petrol boats, railways, automobiles, jet planes	the globe
1960 A.D.	a few hours	Steam boats, railways, automobiles, space rockets	globe -
1963 A.D.	a few minutes	Space satellites	globe
1967 A.D.	–do–	–do–	globe and the moon (?)

We are able to start today from one part of the globe and be in yesterday at another part. We have come to a stage when we have to revise our ideas of time. So much force has this development created, that any number of persons from one country is pushed to the other areas of the globe. People are brought together in trains, buses, ships and in planes. Development of tourism has been the means of welding peoples of different nations together in having not only common means of locomotion but also common habits of wearing dresses, taking food, and sharing ideas.

Along with solving the problem of quicker movement of his family and his belongings, the early man must have been equally worried about communicating his thoughts to others. History has recorded instances when persons, after a long and dangerous voyage across the seas landed in a strange land, met the inhabitants, and tried to tell them of their predicaments. These have been mistaken, for hostility and they have been beheaded. At the instant when the axe was to fall on the neck of one of those heroes of the seas, the fervour, the anxiety, the intensity with which he should have wished he knew the language of his enemies can hardly be described. Even the

English language with all its developments of a rich vocabulary of words can hardly describe the desire of this innocent yet condemned man. The history of the development of the technology of communications of thought starting probably from signs and a few sounds to the present day development of the radio and the television is thrilling. What would have taken hundreds of years, for thought to travel from one end of the globe to the other (globe as it was known in those prehistoric days), it is now possible not only to communicate the same thoughts but even to transmit the photograph of the man from whom the thoughts originated in the matter of a few seconds.

The number of spoken languages must have been legion at one time, gradually reducing to a few hundreds when the art of writing was invented. Each spoken language united a few. The groups knowing languages which were both spoken and written were naturally greater in numbers. With the development of technology of the printing press, the type-writers, the telex services, and the shorthand, and photography, millions of copies of books, magazines, journals, and newspapers are produced. Millions of people have been brought together. They speak the same language, many of them read the same newspapers, and a good many the same books and journals. Development in the technology of' translation service, documentation and library service has further forged greater unity in the methods of communicating one another's thoughts.

Coupled with this development, there has been even more astounding progress in the movement of the thoughts translated into the written word. Long past are the days when letters were carried on horseback from one place to another at great cost. With the development of the paise postage, the trains and the planes, the movement of the written word quickened. It became incredibly faster with the development of the telephone, the radio and the television. Millions and millions are brought together. They can not only converse easily with one another but also have a common share in the enjoyment of radio, televisron and other programmes. The force with which people have been brought together by the progress in this field has been a force to reckon with. It has made a substantial contribution towards forging a one world.

The desire to live as long as possible (if not for all time to come) and to be free from all ailments is an instinctive one. Love of life takes its birth with life itself. At first man thought he could get over disease by propitiating tbe gods with sacrifices of men and cattle. He also found that decoction from certain herbs, and sometimes surgery of the affected parts cured him. From these crude beginnings, grew the highly sophisticated art of surgery, and the science of medicine with its innumerable branches of pharmacology, pathology, biochemistry, etc. Doctors and hospitals have been the focal points for bringing men together. Medicines, drugs, and the special foods for the infants, the invalid and the convalescent are manufactured in millions of bottles. Every improvement of technology in medicine has enhanced the expectation of living. The myth that life of a man was three score and ten was exploded long time back. The force of this technology has brought within one fold, practically the entire humanity to take to one system of medicine, to offer themselves to injections and surgical treatment again of one system, and to carry out vigorously measures advocated by these doctors to protect themselves from the attack of diseases.

Apart from these desires which are basic to our very existence, there are others which arise out of admiration for one's own physical body. Every man, specially women, want to look young and attractive. Out of this desire, the technology of cosmetics, perfumes, soaps, and the like took its origin. The innumerable make-up of the hair, diverse types of costumes and dresses, myriad patterns of jewellery, and similar activities have all come up because of the desire of every person to fight against the aging forces of nature. This desire common in every human being has been the main motivating force to bring together millions wearing the same types of hair, using the same types of cosmetics, soaps, jewellery, costumes and dresses and a thousand other articles. Persons can now change the colour of the hair, remove the hair and put on new makeup, remove wrinkled skins replacing them with fresh ones, replace broken or ugly parts with lovely looking plastic ones, or the like; wear costumes which emphasise only such features which they wish to exhibit, or put on powders, scents and jewellery which make them look young, lovely and attractive. Every advance in this technology has brought revolutionary changes in the exterior appearance of persons, and has given them satisfaction, though often of a temporary nature.

Another natural desire of every man is to work as little as possible, if not avoid working altogether under compulsion. The compulsion in most cases is to work to maintain himself and his family. As already mentioned before, the early races of men spent practically all their time in moving about acquiring food. The desire to escape this drudgery lead to the technology of the development of simple devices like the wheels of the cart, the pulley, the spinning wheel, the pikota (Persian wheel) and the like. From these simple devices, we have moved on to the present age of automatic machines and computors. There are computors which can do calculations in an hour what a thousand men cannot do in their life-time. There are machines which can do in one day, the work of thousands of labourers. There are machines for practically every conceivable job. This has given man plenty of wealth - many times more than he could ever hope to earn by his manual labour, and in addition, lot of leisure. He is now the master of his own time practically every week end, and also for many full days in a year.

No one can dispute that the development in this technology of making machines to increase productivity has brought happiness to millions. This force has brought into existence mass production methods, has brought down prices of articles within the reach of more and more of the population. It has reduced the daily drudgery of cooking, washing and cleaning. This has been responsible in unifying the peoples of the world in using articles produced by such mass production methods, in adopting methods which reduce drudgery of work, and in increasing productivity in divers other ways.

Man is impatient especially when he is hungry and poor. The desire to possess wealth, women or other means of enjoyment or to acquire power over his fellow being has been the cause for many battles. In the early years, this covetousness lead to duels, to bloody fights between groups of tribals, to battles between kingdoms and later on to wars enveloping the whole world. The progress of technology of war, has also been indirectly a progress in bringing unity amongst groups of people. Wars were fought by hurling stones, with bows and arrows, with guns and shells. Technology has so much advanced that wars are fought today with every instrument that can be devised by the ingenuity of man. It is fought on land, on the seas, below the seas, in the air, and in fact at any place, at any time. War is fought not merely by raining bombs and shells between two armies. The entire civilian population is involved. People of one group of countries, millions and millions of them get united with one and the only object of winning the war against an equally determined set of people in another group of countries. In the short space of a few years a war lasts, stupendous advances in technology are made in the methods of mass destruction, in medicine and surgery, in increasing the speed of movement of weapons of war on the land, on the seas and in the air. There is terrific advance in every branch of knowledge. After each war, man gets repentant of his cruelty and exhibition of his basest and the meanest of his qualities. During this century as a result of one war, the League of Nations was born which was an attempt at world unification. At the end of the second war, the United Nations was born which is even a better attempt at world unification. Technology has far advanced after the Second World War. Atomic and hydrogen bombs have been made in such numbers and sizes that they can destroy the entire mankind. Guided missiles have been developed which are certain to convey these monsters of destruction to their destination. Nothing can halt them. Pathogenic bacteria, poison gas, the death rays, and other sure and deadly weapons have been developed. These developments have generated a force so great that it has firmly and securely united the thinking of all men of the world (except a few stupid Chinese) not to precipitate another war. This force of technology of waging wars has no douht wrought terrible destruction. It should not be forgotten that it has been equally powerful in acting as a deterrent against future wars and in binding all people to work in the paths of peace.

Our machine age, while reducing our hours of work, has also brought in its wake, the problem of using our leisure. The desire to enjoy leisure without getting bored, has lead to the development of the technology of the fine arts. The art of writing and reading of books, music, painting, sculpture, dancing and the drama, have thrived from time immemorial. This century has seen the advent of the photographic arts, tbe movies and the television and the radio. In addition tbere are the museums of various types, zoos, aquariums, archealogical monuments and the like which fascinate us. Then we have circuses, sports at national and international levels which display the physical might and skill of men. Development of tourism, whether it be as a pilgrimage or for merely sight' seeing bas been the means of bringing people together. Huge hotels, motels, the choultries (free lodging houses) have also contributed in forging unity in the eating habits of the people. In the past, the enjoyment of the fine arts and its related activities mentioned above was the exclusive privilege of the kings and their selected few. With the advances made in this field of technology, it is now within the reach of everyone. Millions and millions hear the same music on the radio, see the same sights on the television sets, enjoy the same sights of the works of art, or of the animals in a zoo or the fish in an aquarium. Copies of the same book are read by millions. These have been responsible for bringing unity in our tastes, in the appreciation of the fine arts, and the like.

The world has given birth to a gifted few from time to time who have convulsed it by their discoveries in the field of science and technology. These discoveries have been the result not of any ego centred (selfish) urge to secure immediate possession of what they think they require to complete their happiness, but of an inordinate urge to satisfy their curiosity. They are ever after finding out the why and wherefore of the many physical phenomena happening in Nature.

Archimedis wanted to know how he could distinguish pure gold from its alloys. Newton wanted to know why apples of all sizes fall to the ground with the same speed. The great astronomer Varahamira Charya wanted to know how he could exactly predict the advent of the rainy season for sowing seeds, by fixing the exact time taken by the earth to go round the Sun. The great discoveries of Sir Jagadish Chandra Bose, Sir C.V. Raman, Sat yen Bose, and many other Indians and others like Darwin, Faraday. Maxwell, Einstein come under this category. The result of these discoveries has been to tear away superstitions and dogmatic beliefs perpetuated by the many successors of the great founders of religion. If all the rituals and blind beliefs associated with each religion, is torn off leaving only its essence, as Swami Ramakrishna pointed out one will be astonished to find that the experience of the TRUTH has been the same by all religious leaders. Technology has shown conclusively that the wrath of gods are not responsible for thunder and lightning, the storms on the seas, the ravages of plague, cholera and small pox, and a thousand and other events which in the past struck terror into the hearts of the people. The progress of technology in exposing irrational beliefs has been impressive. This desire to know the why and wherefore of things which is synonymous with the technology of scientific method of thinking, has generated a force which has united most of us into a common way of thinking objectively without heat and without fear on all- problems that affect the well-being of humanity.

Again desires of the noblest and the most exalted kind has been the motivating force of the god's chosen few to become leaders to spread His message of 'Shanti' (peace) and 'Prema' (universal love) to one and all. Technology followed by these leaders for spreading their message has varied from time to time. This is one technology where it is difficult to assess whether there has been any progress in its application. Each leader has adopted a technique which was most effective in the period and the environment in which he lived. Each leader, Christ, Mohammed, Buddha, Shankara, Ramakrishna, Ramadas and many others have been responsible for unifying millions and millions of people to one particular way of thinking. This force is easily the mightiest of all the other forces. In fact this is the one and the only force which can bring everlasting happiness to one and all.

We have seen, how every phase of technical activity has lead to unification of groups of men, the size of the group and the duration over which this grouping lasts, varies from one type of technology to another. We have also the other side of the picture. The modern developments in technology have lead to systematic and ruthless exploitation of man by man. It has created slums in cities. Economic independence is now enjoyed by youth, male and female by getting employment at an early age at a salary which enables them to live in greater luxury than their parents. The widespread knowledge of family-planning methods, and the smaller size of present day families have raised the physical standards of living in material comfort. It has also given greater freedom from restraints which our old economy and culture imposed on the moral and social activities of the youth. It has lead to occupational diseases like blood pressure, heart attacks and mental disorders as a result of rise in pressure of work and other anxieties which go with. it in a competitive world. Death and injury by accidents in factories, in travelling by rail, cars, planes and other means of fast movement have increased. This has also resulted in a psychological revolution in thinking. Everybody wants to have the best of everything, with no regard to how it hurts others. This overemphasis on one's own ego has naturally lead to indiscipline everywhere - indiscipline in family life - the children caring a straw for the advice of their parents, the students defying their teachers and elders, the employees breaking all discipline and creating chaos in their relations with their employers and so on.

Inspite of these many failings, man today is more alive and more responsive to the appeals made for living in peace and harmony with one another. We have seen, how every transient desire of man has lead, in the course of history, into a new technological development. We have also seen how everyone of these developments has generated a force with which it has forged one more link in the chain which binds us all together. No two men are identically the same in height, weight, personality, nor are they identical in their requirements of food, clothing, housing, for that matter even in their thinking. Such a mass of diversity is being welded, as though piece by piece, by every technological advancement, ultimately to form the ONE, from which our saints tell us, we have come. There is no doubt, peoples of the world are all moving fast towards their ultimate destination - the realisation of the same ONE in all of us who has within HIM the fountain which quenches for ever our now unsatisfying desire for eternal perfect happiness.

OM Shanti. Shanti. Shanti.

The Trilemma of Technology

Shri J G Bodhe, *MIE*

भूतानां प्राणिनः श्रेष्ठाः प्राणिनां बुद्धिजीविनः ।
बुद्धिमत्सु नराः श्रेष्ठा नरेषु ब्राह्मणाः स्मृताः ॥
ब्राह्मणेषु च विद्वांसः विद्वत्सु कृतबुद्धयः ।
कृतबुद्धिषु कर्तारः कर्तृषु ब्रह्मवादिनः ॥

मनु १.९६.९७

1. Introduction

My co-partners in the technological revolution, Ladies and Gentlemen-

I am indeed honoured by being invited to deliver the Second "Nidhu Bhushan Memorial Lecture" instituted in the memory of the great soul Nidhu Bhushan Chatterji, father of our dear friend Dr. G. P. Chatterji.

My task has been rendered difficult by the stature of both the personalities late Shri Nidhu Bhushan himself and my predecessor Prof. N. S. Govind Rao who delivered the first Lecture last year.

Prof. Govind Rao, a veteran educationalist and a man of profound thought, has emphasized Technology as a World Unifying Force. I, however, propose to highlight the enormity of technological advance that is trying to engulf humanity which is not prepared for it.

The speed with which technology is advancing is such that beth the, technologists and the society are slower to recognise it's implications and to doubt whether it is good for mankind or whether it will lead to the destruction of it. There is, therefore, a heavy responsibility that devolves on the technologists to create a society, to regulate, it and channelise the results of technological inventions, resulting in overall betterment and happiness of mankind.

I have, therefore, drawn profusely on the writings of humanists, leaders of society, great technologists and scientists, to analyse the future trends in social environments in the West and to compare it with that in the underdeveloped countries in the East.

Let me, therefore, share my thoughts with this august body.

THE TRILEMMA

Our civilization faces three great dangers. The first is destruction by nuclear war, the second is being crippled by over population, and the third is the Age of Leisure.

If the first happens, people will know what to do. Most of the civilization may be destroyed, but not all mankind; even some pockets of "white" people will survive here and there. This will face the survivors with a familiar problem, one can perhaps call it an archetypal situation, for which man is psychologically well prepared. As a beetle which has dropped into a glass seems to gather new strength every time when it slips back to the bottom, man will start scrambling up vigorously towards what will then appear as a lost paradise.

If the world is stricken with overpopulation, people will also know what to do. It will be a harsh world, with hard work and strict discipline, and with very little freedom. But though such a crippled life runs contrary to some of man's basic instincts, we know, alas, that men can survive as slaves. So long as the daily bread is a daily victory, there will be enough incentive left to survive.

Only the Age of Leisure will find man psychologically unprepared. Leisure for all is a complete novelty in human history. There have been small earthly paradises before, such as Samoa, or Bali, where people worked little and were satisfied with what they had. The new technological paradise in which the work of a small minority is sufficient to keep the majority in idle luxury is an entirely different matter. It is not yet with us, but it is coming towards us with rapid strides. This is what J. M. Keynes, casting his eyes a few generations ahead, wrote of it in 1930.

We notice with dread the readjustments of the habits and instincts of the ordinary man, bred into him for countless generations, which he may be asked to discard within a few decacies. Must we not expect a general nerbous break-down? We already have a little experience of a nervous breakdown of this sort which is already common enough in England and the United States amongst the women of the well-to-do classes, unfortunate women, many of them, who have been deprived by their wealth of their traditional occupations - who cannot find it sufficiently amusing, when deprived of the spur of economic necessity, to cook and clean and mend, yet are quite unable to find anything more amusing. To those who sweat for their daily bread leisure is a longed-for-sweet until they get it.

Material prosperity and the cold war have made the cost-war world entirely different from the epoch between the two wars. These two factors are of course closely connected, in more than one way. It is a sad but undeniable fact that the enormous military expenditures make it much easier for the West to maintain a satisfactory level of employment. It is also a fact that there is little left now of the torpor, of the sleeping sickness of the inter-war years. The cold war is perhaps the best answer found so far for that 'Moral Equivalent of War' for which William James asked - but evidently it cannot be the final answer.

The reaction of the intellectuals to the post-war epoch was also somewhat different. They are mostly aloof, but looking back this can be considered as progress. We do not know of anything in modern poetry as violently hostile to contemporary life, as was the poetry of T. S. Eliot, which so perfectly fitted the mood of the young people between the two wars. We also find much more benevolence towards humanity in younger historians than there was in Spengler or in Toynbee. Still, it is not difficult to sense the disgust of the intellectuals at the new prosperous working class, 'with their eyes glued to the television screen', who have become indifferent to radical ideas.

The creative imagination we are talking of works on two levels. The first is the level of-social engineering, and the second is the level of vision. Both have lagged behind technology, especially in the highly advanced Western countries, and both constitute dangers.

The present sum of working hours in the West, especially in the United States, is in no way in conformity with the level of our technology. It is kept up artificially, in the first place by enormous defence expenditures, and in the second place by waste. This is only partly a waste of products; to a much larger extent it is waste in unproductive man-hours. The last is summed up in Parkinson's law: 'Work automatically expands so as to fill up the available time.' The tool-pushers who have become unnecessary change into paper-pushers whose numbers can grow beyond any limit because they can always give work to one another. Yet one may be inclined to consider this growth not as a tumour, but as a healthy reaction of a virtuous society, in which people have been brought up to work not only to earn money, but also as they want to feel useful, and to keep their self-respect. Nobody has planned the growth of bureaucracy and of office work in general. It has come about by the unconscious wisdom of the social organism, which can be as admirable as the wisdom of the body, but who can be happy with a prosperity based on defence expenditures, waste and Parkinson's- Law. It can be considered as dangerous, not because it is artificial - but because it is unstable. It is a makeshift device .which will collapse in all probability, and its collapse might lead to war, unless there is the vision to guide us into a stable state.

Some may also argue that the situation today is entirely different because both the Americans and the Russians want to preserve peace. We would even go a step further and credit the leaders on both sides with the best general intentions. Unfortunately, this is far from enough. Let me quote what P. M. S. Blackett said on this point.

"I have not the slightest doubt that the main danger today is not from the rational act of responsible statesmen, but is due to essentially irrational acts of irresponsible, frightened, humiliated, revengeful or just mad people- or perhaps, more likely still, from the confused actions of well-meaning people overwhelmed by complex circumstances beyond their mental or moral ceiling."

This is not a Utopia, neither is it a forecast of the future. We cannot predict the future, nor can we imagine a world' so perfect that it would deserve to remain unchanged forever.

We will start by reviewing the material and social state of our world, in which the greatest dangers and strongest trends are not difficult to detect. They are thetrends towards self-destruction by war, by overpopulation, racial deterioration and instability created by a technology which has taken the bit between its teeth. We take for granted that everybody will agree that these are undesirable trends, however divergent the opinions may be regarding the means of avoiding them. No progress could be made just by fighting present evils without pointing out goals, we will scan, however imperfectly, the future trends of the triple problem and by implication the role of technologists in creating or solving the same.

2. THE FUTURE OF COMPUTERS

The computers themselves and the methods of using them are still developing at breakneck speed. The use of tunnel diodes may raise their speed by a further factor of a hundred. The high-speed memory capacity of the machine - which is now one of the major limiting factors - may be much increased by working at very low temperatures where the electrical resistance of metals entirely disappears. Early in 1964 the Radio Corporation of America claimed to have produced such a store which can memorise, the equivalent of about 5,000 decimal digits on a piece of material 2 inches square and a ten-thousandth of an inch thick.

The computer's memory works at present on what is known as the 'address' system. That is to say, in order to recall a particular piece of information when required, the programme must specify a number that identifies the particular pigeon-hole in which the information is stored. The process is like that of obtaining one's coat from a cloakroom by presenting a numbered ticket. If the ticket is lost, one gets the attendant to search by giving such clues as: "It is a raincoat; light brown; beltless; rather dirty at the collar. I handed it in just before seven, while you were having an argument with a man who sported a ginger moustache." And with this information the attendant finds the coat - not by knowing where it is, but by knowing that it is associated with the properties like 'light brown' and 'dirty round the collar'. The human mind, when solving a problem, uses its memory in a way that is much closer to this method than to the numbered ticket syntem. "An Associate Memory System" (as it is called) if' less precise than an address system, but much more flexible; it lies at the root of the more creative aspects of thinking, when the mind searches associations to discover something that might be relevant to the problem in hand. Already computer stores can be arranged to reproduce some very simple cases of finding information by association - they could solve the problem of the lost cloak-room ticket if it were worth the trouble. And we have the prospect that the associative stores will in the future greatly increase the complexity of problems that computers can tackle, bringing them closer to human ways of thinking.

We are, therefore, only at the start of the computer age. In the not very distant future we may have computerised information system that store all the knowledge of the world's libraries, and can produce any piece of it on request, not only when we can say exactly what we want, but also (using associate stores) when we can say rather vaguely the sort of thing we want (for example, 'any facts or any speculations by others that might help me to understand why literary researches by computers have concentrated on theological questions.' We may have other machines fed with up-to-the-minute data on all that is going on in industry, agriculture and commerce, continually analysing and collating this information, and ready at a moment's notice to provide the essence of any part of it, in order that some economic decision can be taken on a fully rational basis. At present, computers which have been instructed in the little we know about, how weather systems develop are giving modest help to forecasters. In future we may tell our meteorological computer what we know, feed it continually with new information on temperatures, pressures and the like, and leave it to discover trends in weather development which the complexity of the data would prevent us from finding out for ourselves, Computers storing all the medical information about the population (assuming greatly improved health services, so that the medical state of every individual is thoroughly known) could give us far greater powers in the control and prevention of disease. Already there are demonstration machines that can obey instructions given verbally, provided one speaks carefully and sticks to a vocabulary of a dozen words or so. In future a computer may 'listen' to the speeches at an international conference and almost instantaneously speak the translations in other languages. And in all this we have again done no more than predict that computers will enable us to do efficiently and speedily things that we already do clumsily and slowly. But surely, when we really come to understand them, they will also help us to do things that at present we cannot even imagine.

Already computers are relieving us of much of the drudgery of routine brain work. And soon this sort of mental hack-work will be entirely taken over by – electronic slaves. Whether computers do (or will in future) think is probably a meaningless question. But certainly they can do for us a very great deal of the work that we do by thinking and will be able to do much more. We can imagine the time coming when the scientist or scholar at work on a piece of creative thinking has the input and output connections of a computer at his elbow. Some new idea requires a lot of mental hack-work to test and develop it. But instead of devoting his brain-power for the next few weeks or months to this low grade drudgery, he speaks to his computer. By virtue of its superior speed, the computer gets through this hack-work in a few seconds and tells him the result, and he can get on with the next creative step in his work.

All this does not mean that we shall be encouraged to become mentally lazy. On the contrary one has to think much harder to provide the problems that are to keep the computer going. Its function is not to reduce the amount of our thinking, but to relieve us of the simpler types of mental work and so leave us free for more creative thought, while at the same time greatly increasing the effectiveness of the whole process.

3. SCIENCE AND VALUES

With Tolstoi and Aldous Huxley, and to a lesser extent even Swift and Wells, the focus of interest shifts from the aesthetic to the ethical aspects of science. Science itself depends for its life on the prior acceptance of certain fundamental values such as the value of curiosity and learning. the value of truth, the value of sharing knowledge with others, the value of respect for facts, and the value of remembering the vastness of the universe in comparison with the finite knowledge of men at any particular moment. Historically, such values have been held by outstanding scientists. One thinks of P. W. Bridgman's well-known dictum that - "in the face of the fact, the scientist has a humility almost religious", or of Newton's description of his own work as the play of a child with pebbles on the shores of the ocean of knowledge, or his reference to the sharing of knowledge with others by describing his own achievements as being due to his having stood "on the shoulders of giants". Beyond such evidence, it could perhaps be shown that the cumulative work of science could not go on if any of the values just listed were rejected.

As science rests on certain values, so do almost all values depend on knowledge, and thus to some extent in turn on science, if they are to proceed from the realm of words to that of action. This implies a circular chain of causation or a feedback process, as do many processes of social and cultural development. To act morally is in one sense the opposite of acting blindly. It is acting in the presumed knowledge of what in fact it is that we are doing. Almost every significant action of this kind implies serious assumptions in some field of science. To love one's neighbor requires at the very least that we find out where and who our neighbor is. If we are to respond to his needs we must first ascertain what his needs are and what action in face is likely to be helpful to him. To feed the hungry requires first of all the ability to distinguish food from poison, as well as the ability to provide food or produce food when needed. The same principles apply, of course, to clothing the naked or healing, the sick. Indeed, it can be said that perhaps no action can be evaluated as good or bad without some knowledge or surmise about its consequences.

Attempts at hermetic separations of science from values are thus bound to fall. Science without at least some values would come to a dead stop; ethics without at least some exact and verifiable knowledge would be condemned to impotence or become an engine of destruction. Much of the anxious discussion of international politics between statesmen and atomic scientists, or between the so-called schools of "idealism" and "realism" among political writers, hinges upon the discrepancy between the strength of the moral convictions involved and the poverty of reliable knowledge of the probable consequences of the proposed courses of action.

The relationship of science and values thus implies a double question: the mutual interrelation of science and the general values of a civilization; and the relationship of a specific state of scientific knowledge to the pursuit of specific purposes or policies. The first of these problems, the general relationship of science and value, and thus to some extent of truth and goodness, leads us close to the heart of every civilization within which it is examined. If convinced as mutually incompatible, science and values may frustrate or destroy each other, dragging their civilization towards stagnation or decline. As a mutually productive and creative partnership, science and values may suceed in strengthening each other’s powers in a self-enhancing pattern of growth, rendering their civilization increasingly open and able to learn from the hopes and dreams of the individuals within it, as well as from the universe around it.

We might, similarly decide to bet on the potential goodness rather than on the potential evil of knowledge, arid concentrate on providing a human and social-environment for science, in which its constructive possibilities are likely to, be realized. It is possible, of course, to imagine extreme situations for some times and places in which the short-term potentialities for destruction might seem so great in the case of a particular invention or discovery, and the prevailing political regime might seem so unlikely to avoid its suicidal misuse, that a policy of temporarily restricting, delaying, or withholding such knowledge might appear as the least of several likely evils for the time being. Even granting all these assumptions, however, such a policy of fear of knowledge would have to be viewed as extremely transitory and exceptional in any modern technological civilization that is to continue to advance or indeed to survive. A civilization so prone to commit suicide that it could be saved only by concealing from it the means of it own destruction would not endure for long. Rather, for the-long run and for most conditions that are likely to occur, we might do better to adopt the opposite assumption; that any modern civilization that is to endure will have to learn how to live with its new knowledge of its vast means of destruction.

4. CRISIS OF OUR THERMO-NUCLEAR AGE THE COSMIC CIVILIZATION

Man's scientific knowledge has crossed the Rubicon today: it has ultimately stamped its invincible m~rk of domination over the entire domain of the mysteries of Nature — the so-called baffling and bewildering mysteries, which the great English dramatist Shakespeare interpreted thus: "there are more things on this earth and in heaven than are dreamt of in thy philosophy......". The suprascientific know ledge of man, having tamed the awsome elements of material realm, has soared higher to unmask the hitherto known as the eternally cloistered mysterious face of space and succeeded in criss-crossing the entire mighty expansion of unlimited cosmos. The space has been conquered and modern man, guided and inspired by the great leader-teacher, Science, is out to set up an inter-planetary civilization, after conquering space. While we are out to usher in a splendidly unique inter-planetary civilization, guaranteeing free and unrestricted space' communications between our earth and the distant planets, including Moon, we have not been able to guarantee safe and free traffic flow between London, New York, Tokyo, Bombay and their suburbs. Is this not irony of human evolution!

SPIRITUAL DISINTEGRATION

The theme of the drama of our modern life is indeed, of the coming closer and together of men and of the human society becoming something of 'cosmos'. Nevertheless, we are daily getting disintegrated amid all the factors that can contribute to the grand integration of the human world. It is the result of our perverted scientific genius, which again tends to lead us to a stagnant state of spiritual and ethical bankruptcy. "The giant strides, Science has taken in the physical, natural, industrial, mathematical and technological spheres have left in their wake a proud world bereft of social and moral values - a world forgetful even of the existence of a person God, the Sole Author of every Science."

Bergson, in a well-known phrase, has said that modern man needs "a bit more soul". Ours is a soul-less civilization of mechanical temper. The spirit that dominates the life of modern man is the spirit of the machine. Like an unbridled and unsaddled wild horse, like an over-drunken gladiator, modern science has become the greatest terror to man. Terror-stricken, the peoples of the world have had to witness a newly planned immense advancement of the means and arts of an inner decay, which through the hardening of the moral sensibility, precipitates the complete suppression of every sentiment of humanity and rushes them towards a darkening of reason and deadening of the soul.

If we are to re-build our civilization, we have first to build again the walls that have been pulled down. The science, philosophy and art will once again recover their lost significance. Without the recognition of an end which totally transcends this world, science can only become a system of idols; philosophy can only contemplate the meaninglessness of human existence; art can only disintegrate into fragments; politics will continue in its fostering of the germs of Cold War; and economies will go on fer getting the ethical maxim that man does not live by bread alone. "Attempt at international solidarity can yield fruit only if the doctrine of the Brotherhood of Man is supported by an ethical belief in the Fatherhood of God."

The irony, however, is that we refuse to recognize our inner values and lIke a perverted child. would go on crying for the moon - to achieve the unachievable. We have, dogmatic-ally, been changing to the final image of a scientific civilization which breeds 'crisis after crisis. The 'result is that our modern age has become a crisis-laden nge in – a problem-ridden world. As soon as one crisis is being bridged over, another crisis raises its hood of poison.

5. ATOMIC HOLOCAUST

If an insane world 'power chooses to destroy United State-of America, it will estimate as follows:

1. To kill 60 per cent of the U.S. population (about 120,000,000 people): 500 10-megaton bombs dropped on centres of industry.

2. To destroy 100 per cent of the port capacity of the U.S.: Forty 10-megaton bombs (400 megatons total) dropped on ports

3. To destroy 100 per cent of petroleum refinery capscity of the U.S. : 150 10-megaton bombs dropped on petroleum refineries.

4. To destroy 90 per cent of U.S. heavy industry: 300 10-megaton bombs (3,000 megaton total) dropped on centres of such industry.

5. To burn out about 10,000 square miles of vegetation: One 10-megaton bomb. Under very "favourable" conditions in the forest area a single 1-megaton bomb would burn out about 8,000 square miles.

6. To burn all vegetation on 50 per cent of the U.S. land area: an attack with a total of about 7,500 megatons of weapons. (Estimates are extremely variable: the area that would be burned out in a 1,500-megaton attack has been estimated at from 5 to 80 per cent of the total U.S. area).

7. Tho destroy by fall-out radiation the usefulness of 91 per cent of U.S. crop land and to destroy 95 per cent ot hog production, 94 per cent of milk production and 88 per cent of all cattle: an attack totalling 23,000 megatons on combined military and population targets.

Taking into account these effects (which assume that bembs are delivered to different targets with complete accuracy), the probable inaccuracy of missile (which is rather small), and the different possible patterns of attack, we can arrive at a general estimate of the overall destruction. An attack of 5,000 to 10,000 megatons would not immediately "wipe out" the nation; some people (about 30 per cent), and some food-producing capacity (something less than 50 per cent) would remain. A heavier attack — at the 23,000 to 25,000 megaton level which might be possible in the 1970s — would reduce the surviving proportions of people and industry to perhaps 10 per cent of their former value. "Total" obliteration, at least as an immediate consequence to attack, would require a considerable increase over the 25,000 megaton level. It might be achieved by radiological warfare involving deliberate land contamination with cobalt 160, or by a 23,000 to 25,000 megaton attack followed by intensive chemical and biological warfare.

But these numbers do not tell the whole story. A major nuclear attack could not only drastically reduce the size of the surviving population, but would also markedly change its composition. Because of the uneven geographical distribution of people engaged in various professions, those occupations most important in national recovery would be especially hard hit. Thus a 2,000 megaton .attack could kill 73 per cent of the nation's architects, 69 per cent of the chemists, 62 per cent of the physicians, 72 to 86 per cent of various kinds of engineers (with the exception of mining engineers), 64 per cent of all machinists, 76 per cent of tool and die makers.

Expenditure on military redearch and development, all defence departments

Period	United Kingdom (£ million)	United States of America. ($ million)
1938 - 1939	5·7	NIL
1939 - 1940	7·9	26·4
1947 - 1948	40·0	529·2
1951 - 1952	80·0	821·0
1953 - 1954	100·0	1569·2
1956 - 1957	204·0	1407·9
1960 - 1961	228·0	8400·0
1964 - 1965	250·0	13400·0

(1) in considering the meaning of these figures, allowance must be made for the factor of inflation. At 1953 prices, the United kingdom figure would be £210 million, i.e., in real term it had more than doubled in ten years. (£=2·8 dollars at the current exchange rate.

6. OVERPOPULATION

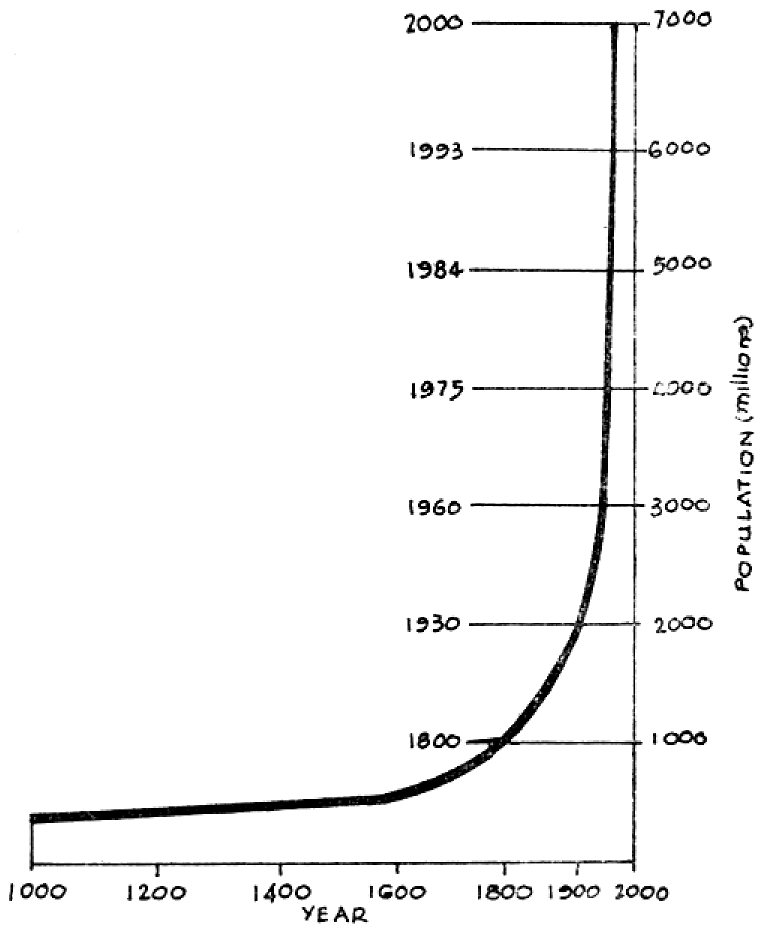
For anybody who wants to look into the future the unexpectedness with which the problem of overpopulation has burst upon us after the Second World War is sobering, and even discouraging.

One may look at the unforeseeable turn which world population trends took shortly after 1935, as shown by the graphs on the next page and by the following figures:

Year	1920	1930	1940	1950	1960
World Population in millions	1,810	2,013	2,246	2,495	2,970

If one had extrapolated these figures in the year 1940 to the year 2000 with the rate of increase between 1930-40 one would have arrived at 4.4 billion, taking into account the decreasing rate from 1920 to 1940, the result would have been nearer 3.5 billion and this was indeed at that time the figure considered as the most reliable estimate. Repeating the calculation in 1960 the estimate would have been almost 6 billion on the basis of the rate of the last ten years, and almost 7 million, taking into account the increasing rate in the last twenty years.

This is sufficient to caution anybody who wants to make a forecast even for the relatively short span of forty years. Only one thing is certain, the population of the world is increasing at an alarming rate.



POPULATION OF THE WORLD has increased enormously in the past 300 years. By 1800 about a million years since his beginnings – a man had built up a population of 1000 million. Since then, however, the periods between successive increases of 1000 million have progressively shortened. For the population to incre ase from 6000 million to 7000 million could take only 7 years (1993 to 2000). such explosive growth can be attributed at least in part to improved nutrition and standards of hygiene in the developing countries.

It is clear from the graphs of birth and death rates, we must distinguish between two very different types of population growth. One is the population "explosion" in the backward countries, which is due entirely to the fall of the death rate, and at steady or even slowly falling birth rates (It is entirely wrong to think that these poor natives have indulged in an orgy of procreation). The other type is the upsurge of population in the industrially most advanced countries, due to an unexpected increase of the birth rate at a very low and still slowly dropping death rate. Around 1930 it was expected that the population of the United States would level out around 145 million. It has already topped 186 million.

If we want to look far ahead we can consider the poulation explosion in the backward countries as a tragic but temporary phenomenon. The population of India, for instance, grew between 1950 and 1955 at the rate of 5 million a year, in the next five years at the rate of 7 million, and the present growth has been put at 10 million. The Indian population was about 345 million in 1947, but in 1966 it reached 480 million and in spite of frantic efforts the agricultural development has lagged far behind this rate. Barring a succession of bumper harvests or greatly increased foreign food supplies one must expect many millions of Indians and other Asiatics will suffer from starvation before the end of the century. But however tragic this may be, one can consider it as a passing phenomenon. Sooner or later, with increased industrialization and education the birth rate will fall to adjust itself to the lower death rate. This process is well on the way in Japan, where the birth rate was cut in half but not before the population of those small and infertile islands had risen to 92 million, and the density of population to more than 4,600 per square mile.

The crucial question is at what density the equilibrium will be reached: at the Malthusian starvation level, or at something more worthy of the dignity of man? This is why we must scrutinize the situation in the advanced countries rather than that in the backward regions. Thirty years ago, at the time when Margaret Sanger agitated for a "birth strike" one would have confidently predicted that the population in the rich countries would become steady at the level which was actually reached around 1950, and that the individual would fully benefit from the progress in national wealth. This has now become more than doubtful. It has turned out that in our healthy and virtuous civilization people whose livelihood is assured, and who could think of new and rare luxuries, have turned back instead to the simple pleasure of their ancestors: the joy of having large families. But this is just the one luxury our civilization cannot afford. Our ancestors could afford to have many young children around them because they paid a price for it which we would not be willing to pay viz, seeing many of them die young. At our stage of hygiene and medicine, large families — of an average of about 2-3 children per family — are synonymous with a rapidly increasing population.

We can call the increase of birth rate in the advanced countries a defence mechanism against the Age of Leisure, and this is what it is, not only socially but individually and psychologically. Nobody can doubt this, who knows young American middle-class couples with 4-6 children. Rich as they are measured by world standards, it. means a sacrifice to them, but what is this compared with the necessity of giving an outlet to the tremendous energy of the young American woman? As regards the men, when asked what workmen would do with more leisure time, the American labour union leader - Walter Reuther, replied characteristically : They would have more time for their kids. This is an admirable reply and it is painful that one has to comment that in a civilization, in which child mortality is almost non-existent, adult people will have to look for other pastimes than playing with young children.

Almost everybody will agree that overpopulation will have to be stopped by birth control - some time.

Admittedly, the first stages of the fight against hunger are beautiful and inspiring. Reclaiming land from the sea, as the Dutch have done for centuries, or turning the desert into orange groves as the Israelis are doing now, brings out most of the best in men. But these are ancient techniques. To show what new technologies might do; let us think for a moment a little science-fiction of the nastiest sort.

Assuming that at some time in the future, reason will prevail all over the world, an agreement may corrie about on the optimum population density. The area which a man requests for his food may have been about one square mile in the time of the nomadic hunters, it has shrunk to about half an acre with modern methods of agriculture, allowing a — population of about 1,300 per square mile of fertile land. By-this measure the U.S. with about 60 persons per sq. mle. is grossly underpopulated. Europe with 716 is still comforfable, while-the "ECAFE" region (Asia and the Far East, east of Siarn) with 9.75 in an area which contains many deserts, is critical, and Japan with 4,600 p.sq.mle. is overpopulated by any standard. About 10-15 per cent of the world's population of 3 billion suffer from chronic under-nouzishmerit, about half from malnutrition, by monotonous food deficient in proteins and vitamins. Solving this problem by redistribution of the populations, such as allowing the Chinese to flood into Siberia or into the Americas, and the Africans into Europe could be contemplated only in a nightmare. Feeding the excess millions — at least 1000 but possible 3000 million by the end of the century —will have to be achieved, in the areas where they are now, with as much help from the few surplus producing areas of the world as possible — but there is scant hope that the problem will be satisfactorily solved. At the best there wiil be a stunted, under-nourished population in the Far East, but at tbe worst a great part of the excess population will becondemned, to death by, starvation.

But even if it were possible to feed, say 6 billion people according to modern-health standards, nobody could be satisfied with it, except perhaps the people who still remember starvation — so long as they remember it. A hungry man wants nothing but food, but the man with a full belly asks far more, or else he is not a man. The modern European asks for a car per family — the American for two large cars — with garage, parking places, and a little free road between bumper and bumper. Everybody knows that he is frustrated even in these modest demands. The private car is undoubtedly an expression of personal freedom, or at any rate it was so intended. It was not expected to be the last invention in the line of personal freedom. Between 1900 and 1931 every self-respecting Utopian writer gave private helicopers to the men of the future, even before it was invented. The helicopter is now invented, engineered and safe, but there can be no question of private helicopters except in very sparsely inhabited places. Overpopulation has blocked a fine avenue for adventure before it was ever open.

Modern man also wants playing fields, golf courses, football fields, tennis courts. Will these be declared antisocial as they occupy areas where wheat or corn could grow? He also wants to see a little of unspoilt nature, and this is where frustration strikes him worst. Not so long ago there was much beautiful free country within walking distance of New York, Paris, London and Bombay. The motor-car has made everybody, who could afford it, flee the cities - some of them masterpieces of human culture which may soon change into slums - and ribbondevelopment, and cluttered up the approaches for miles and miles.

For a prosperous civilization even the Western population density is already well beyond its optimum. This was not obvious so long as only a very small fraction of the population could travel, but now millions can afford it, and it is pitiful to behold the masses which are ushered as fast as possible through the Piazza San Marco or the Louvre, or who try to enjoy themselves in the seaside places, but hardly able to get a glimpse of the sea.

We are going the wrong way, as fast as we can, the East into starvation, the West into frustration. At the moment the best we can hope is that the East following the example of Japan will stop its headlong rush into famine. In the West we cannot even start to preach reason. How can we persuade these nice, loving and lovable young people to forego the pleasure of large families? If not even the danger of the hydrogen bomb can change their mind, what hope is there of persuading them without coercion? This is a grave question to answer.

7. POLLUTIONS OF ENVIRONMENTS AND RESPONSIBILITY OF SCIENTISTS

High productivity results in high undesirable waste products and pollution of air, water and soil.

According to report by the Committee on Pollution, National Academy of Sciences, we need to plan for a complete transformation of urban waste-removal systems, in particular to end the present practice of using water to get rid of solid wastes. The necessary technological problems involved are so complex that the report recommends, as an initial step, the construction of a small pilot-city to try out the new approach.

The high productivity of American agriculture, and therefore its economic structure, is based on the use of large amounts of mineral fertilizers in which phosphate and nitrate are major components. This fertilizer is not entirely absorbed by the crops and runs off into streams and lakes. As a result, by nourishing our crops and raising agricultural production we help to kill off our lakes and rivers. In the absence of any foreseeable means of removing fertilizer run-off from surface waters, it will become necessary, to impose severe restrictions on the present unlimited use of mineral fertilizers in agriculture. Proposed restraints on the use of synthetic pesticides have already aroused a great deal of opposition from the chemical industry and from agriculture. Judged by this response, an attempt to regulate the use of mineral fertilizers will confront us with an explosive economic and political problem.

And suppose, that the accumulation of carbon dioxide begins to threaten the entire globe with catastrophic floods. Control of this danger would require the modification, throughout the world, of domestic furnaces and industrial combustion plants, for example by the addition of devices to absorb carbon dioxide from flue gases. Combustion driven power plants could perhaps be replaced with nuclear ones, but this would pose the problem of safe disposal of massive amounts of radio-active wastes and create the hazard of reactor accidents near centres of population. Solar power, and other techniques for the production of electrical power which do not require either combustion, or nuclear reactors, may be the best solution. But, here too, massive technological changes in all industrial nations will be needed.

The problems of industrial and agricultural pollution, while exceedingly large, complex, and costly, are, nevertheless, capable of correction by the proper technological means. We are still in a period of grace and if we are willing to pay the price, as large as it is, there is yet time to restore and preserve the biological quality of the environment. But the most immediate threat to survival — nuclear war — would be a blunder from which there would be no return. We know of no technological means, neither from civil defence or counter-offensive warfare, which could reliably protect the biosphere from the catastrophic effects of a major nuclear war. There is, only one way to survive the threat of nuclear war — and that is to ensure that it never happens. And because of the appreciable chance of an accident nuclear war, we believe that the only way to do so is to destroy the world's stock of nuclear weapons and to develop less self-defeating means of protecting national security. Needless to say the political difficulties involved in international nuclear disarmament are monumental. It is said that U.S.A. had a stock pile of 60,000 megatons capacity of nuclear weapons and Soviet Russia having about 20,000 to 30,000 megatons.

Despite the dazzling success of modern technology and the unprecedented power of modern military systems, they suffer from a common and catastrophe fault. They provide us with a bountiful supply of food, with great industrial plants, with high-speed transportation, and with military weapons of unprecedented power - but they threaten our very survival. Technology has not only built the magnificent material base of modern society, but also confronts us with threats to survival which cannot be corrected unless we solve very grave economic, social and political problems.

How can we explain this paradox? The answer is, that our technological society has committeed a blunder familiar to us from the nineteenth century, when the dominant industries of the day, especially lumbering and mining, were successfully developed — by plundering the earth's natural resources. These industries provided cheap materials for constructing a new industrial society, but did so by accumulating a huge debt in destroyed and depleted resources, which has to be paid by later generations.

The earlier ravages of our resources made very visible marks, but the new attacks are largely hidden. Thoughtless lumbering practices left vast scars on the land, but thoughtless development of modern industrial, agricultural and military methods only gradually poison the air and water. Many of the pollutants — carbon dioxide, radioisotopes, pesticides and excess nitrate — are invisible and go largely unnoticed until a lake dies, a river becomes foul, or children sicken. This time the world is being plundered in secret.

The earlier depredations on our resources were usually made with a fair knowledge of the harmful consequences, for it is difficult to escape the fact that erosion quickly follows the deforestation of a hillside. The difficulty lay not in scientific ignorance, but in wilful greed. In the present situation, the hazards of modern pollutants are not geenrally appreciated until after the technologies which produce them are well established in the economy. While this ignorance absolves us from the immorality of the knowingly destructive acts that characterized the nineteenth-century raids on our resources, the present fault is more serious. It signifies that the capability of science to guide us in our interventions into nature has been seriously eroded — that science has, indeed, got out of hand.

In this situation, scientists bear a very grave responsibility, for they are the guardians of the integrity of science. In the last few decades searious weaknesses in this system of principles have begun to appear. Secrecy has hampered free discourse. Major scientific enterprises have been governed by narrow national aims. In some cases, especially in the exploration of space, scientists have become so closely tied to basically political aims as to relinquish their traditional devotion to open discussion of conflicting views on what are often doubtful scientific conclusions.

What can scientists do to restore the integrity of science, and to provide the kind of careful guidance to technology that is essential if we are to avoid catastrophic mistakes? No new principles are needed; instead scientists need to find new ways to protect science itself from the encroachment of political pressures. This is not a new problem, for science and scholarship have often been under assault when their freedom to seek and to discuss the truth becomes a threat to existing economic or political power. The internal strength of science, and its capability to understand nature, has been weakened whenever the principles of scientific discourse were compromised, and restored when these principles were defended. The medieval suppressions of natural science, the perversion of science by Nazi racial theories, Soviet restraints on theories ot genetics, and the suppression by U.S. military secrecy of open discussion of the Starfish project, have all to be paid for in the most costly coin, knowledge. The lesson of all these experiences is the same — if science is to perform its 'duty to society, which is to guide, by objective knowledge,' human interactions with the rest of nature, its integrity must be defended.' Scientists must find ways to remove the restraints of secrecy, to insist on open discussion of the possible consequences of large-scale experiments before they are undertaken, to resist the hasty and uncondition support of conclusions that conform to the demands of current political or economic policy.

RESPONSIBILITY OF SCIENTISTS

Apart from these duties towards science, scientists have a responsibility in relation to the technological uses which society derives from scientific progress. The proper duty of the scientist to the social consequence of his work can be fulfilled neither by aloofness, nor by an approach which arrogates to science the social and moral judgments which are the right of every citizen. Scientists are now bound by a new duty which adds to and extends their older responsibility for scholarship and teaching. We have the duty to inform in keeping with the traditional principles of science, taking into account all relevant data and interpretations. This is, an involuntary obligation to society; we have no right to withhold information from our fellow ctizens, or to colour its meaning with our own social judgments.

Scientists alone cannot accomplish these aims, for despite its traditional and independent scholarships, science is a dependent segment of society. In this sense defence of the integrity of science is a task for every citizen. And in this sense, too, the fate of socience as a system of objective inquiry, and therefore its ability safely to guide the life of man on earth, will be determined by social intent. Both awareness of the grave social issues generated by new scientific knowledge, and the policy choices which these Issues require, therefore become matters of public morality. Public morality will determine whether scientific inquiry remains free, P'ublic morality will determine at what cost we shall enjoy freedom from insect pests, 'the' convenience of automobiles, or the high productivity of agriculture. Only public morality can determine whether we ought to entrust our national security to the catastrophic potential of nuclear war.

There is a unique relationship between the scientist's social responsibilities and the general duties of citizenship. If the scientist, directly or by inferences from his actions, lays claim to a special responsibility for the resolution of the policy issues which relate to technology, he may, in effect, prevent others from performing their own political duties. If the scientist fails in his duty to inform citizens, they are precluded from the greatest acts of citizenship and lose their right of conscience.

In recent times the gap between traditional moral principles and the realities of modern life has become so large as to precipitate, beginning in the Catholic church, urgent demands for renewal — for the development of statements of moral purpose which are directly relevant to the modern world. But in the modern world the substance of moral issues cannot be perceived in terms of the casting of stones or the theft of a neighbour's ox. The moral issue of the modern world are embedded in the complex substance of science and technology.

Nowhere is this more evident, or its solution more urgent, than in the case of nuclear war. The horribleness of nuclear war can only be described in scientific terms. It can be pictured only in the language of roentgens and megatonnage; it can be understood only by those who have some appreciation of industrial organization, of human biology of the intricacies of world-wide ecology. The self destructiveness of nuclear war lies hidden behind a mask of science and technology. It is this shield, which has protected this most fateful moral issue in the history of man from the judgment of human morality. The greatest moral crime of our time is the concealment I of the nature of nuclear war, for it, deprives humanity of the solemn right to sit in judgment on its own fate; it condemns us all, unwittingly, to the greatest dereliction of conscience.

The obligation which our technological society forces upon all of us, scientist and citizen alike, is to discover how humanity can survive the new power which science has given to it. It is already clear that even our present difficulties demand far-reaching social and political actions. Solution of our pollution problems will drastically affect the economic structure of the auto industry, the power Industry, and agriculture, and will require basic changes in urban organization. To remove the threat of nuclear catastrophe we will be forced — at last — to resolve the pervasive international conflicts that have bloodied nearly every generation with war.

Every major advance in the technological competence of man has enforced revolutionary changes in the economic and political structure of society. The present age of technology is no exception to this rule of history. We already know the enormous benefits it can bestow, and we have begun to perceive its frightful threats. The political crisis generated by this knowledge is upon us.

Science can reveal the depth of this crisis, but only social action can resolve it. Science can now serve society by exposing the crisis of modern technology to the judgment of all mankind. Only this judgment can determine whether the knowledge that science has given us shall destroy humanity or advance the welfare of man.

8. THE BIOSPHERE

What we know about living things and about the biosphere — the community of life in the environment — is that they are exceedingly complex, and that this complexity is the source of their remarkable staying power. The web of relationships that ties animal to plant, prey to predator, parasite to host, and all to the air, water, and soil which they inhabit, persists because it is complex. An old farmhouse practice is a simple illustration of this fundamental point. Farmers who keep cats to control the ravages of mice find it necessary to offer the cats a doorstep feeding. Only if the farmer provides this alternative source of food can the cats withstand a temporary shortage in the mouse supply and remain on hand to catch the mice when they reappear. A stable system that will keep mice in check must comprise all three components: cats, mice and domestic cat food. This principle is well established in environmental biology: anything which reduces the complexity of a natural biological system renders it less stable and more subject to fatal fluctuations.

The biosphere is closely governed by the connections among its numerous parts. The connections which comprise the biological food chain, for example, greatly amplify the effects of environmental pollution. If soil contains one unit of insecticide per gram, earthworms living in the soil will contain 10 to 40 units per gram, and in woodcocks feeding on the earthworms the insecticide level will rise to about 200 units per gram. In the biosphere the whole is always greater than the sum of its parts; animals which absorb one insecticide may become more sensitive to the damaging effects of a second one. Because of such implifications, a small instrusion in one place in the environment may trigger a huge response elsewhere in the system. Often an amplification feeds on itself until the entire living system is engulfed by catastrophe. If the vegetation that protects the soil from erosion is killed, the soil will wash away, plants will then find no footholds for their seeds, and a permanent desert will result.

It is not surprising, then, that the introduction of any killing chemical into the environment is bound to cause a change somewhere in this tangled web of relationships. For this reason, and because we depend on so many detailed and subtle aspects of the environment, any change imposed on it for the sake of some economic benefit has a price. For the benefits of powerful insecticides, we pay in losses to bird-life and fish. For the conveniences of automobiles, we pay in the rise of respiratory disease from smog. For the widespread use of combustible fuels, we may yet be forced to pay the catastrophic cost of protecting our cities from world-wide floods. Sooner or later, wittingly or unwittingly, we must pay for every instrusion on the natural environment.

DANGEROUSLY INCOMPLETE KNOWLEDGE

There is considerable scientific disagreement about the medical hazards of the new pollutants: about the effects ot DDT now found in human bodies, about the diseases due to smog, or about the long-range effects of fall-out. But the crucjal point is that we have risked these hazards before we knew what harm they might do. Unwittingly we have loaded the air with chemicals that damage the lungs, and water with substances that interfere with the functioning of the blood. Because we wanted to build nuclear bombs and kill mosquitoes, we have burdened our bodies with strontinum-90 and DDT, with consequences that no one can now predict. We have been massively intervening in the environment, without being aware of many of the harmful consequences of our acts until they have been performed, and the effects - which are difficult to understand and sometimes irreversible - are upon us. Like the sorcerer's apprentice, we are acting upon dangerously incomplete knowledge. We are, in effect, conducting a huge experiment on ourselves. A generation hence – too late to help — public health statistics may reveal what hazards are associated with these pollutants.

To those of us who are concerned with the growing risks of unintended damage to the environment, some would reply that it is the grand purpose of science to move into unknown territory, to explore, and to discover. They would remind us that similar hazards have been risked before, and that science and technology cannot make progress without taking some risks. But the size and persistence of possible errors has also grown with the power af science and the expansion of technology. In the past, the risks taken in the name of technological progress, boiler explosion on the first steamboats, or the early injuries fromr adium, were restricted to a small place and a short time. The new hazards are neither local nor brief. Air pollution covers vast areas. Fall-out is world wide. Synthetic chemicals may remain in the soil for years. Radio-active pollutants now on the earth's surface will be found there for generations, and in the case of carbon-14, for thousands of years. Excess carbon dioxide from fuel combustion might eventually cause floods that could cover much of the earth's present land surface for centuries. At the same time the permissible margin for error has become very much reduced. In the development of steam engines a certain number of boiler explosions were tolerated as the art was improved. If a single comparable disaster were to occur in a nuclear power plant or in a reactor-driven ship near a large city, thousands of people might die and a whole region rendered uninhabitable — a price that the public might be unwilling to pay for nuclear power. The risk is one that private insurance companies have refused to underwrite. Modern science and technology are simply too powerful to permit a trial and error approach.

It can be argued that the hazards of modern pollutants are small compared to the dangers associated with other human enterprises. For us, the fall-out hazard is, for example, much smaller than the risks we take on the highway or in the air. But what of the risks we inflict on future generations? No estimate of the actual harm that may be done by fall-out, smog, or chemical pollutants can obscure the sober realization that in each case the risk was undertaken before it was fully understood. The importance of these issues to science — and to the citizens — lies not only in the associated hazards, but in the warning of an incipient abdication of one of the major duties of science — prediction and control of human interventions into nature. The true measure of the danger is not represented by the present hazards, but by the disasters that will surely be visited upon us if we dare to enter the new age before us without correcting this basic fault in the scientific enterprise. And if we are to correct this fault, we must first discover why it has developed.

9. THE COMING CONQUEST OF SPACE

Let us look into the future. The space we have started to explore is vast, almost beyond imagination. To get an idea of it, let us consider a scale model in which the Earth is represented by a globe 6 inches in diameter. The distance across the Solar System on that scale is about 90 miles. The Luniks and Rangers have shown that we can reliably send instruments the mere 16 feet to the Moon. Beyond that, we still depend on a great deal of luck, but Mariner II sent back infomration about Venus from a distance of some 750 yards, and our record so far is the signals from the Soviet Mars probe at 1,400 yards. As to manned flight, the three-man team of October 1964 circled this 6-inch globe a mere fifth of an inch above its surface! Obviously we have a long way to go before we can master the exploration of even the Solar System.

Yet it seems clear that space journeys throughout the Solar System can be achieved by the development of techniques of rocketry we already know, or perhaps using nuclear-powered rockets, ion rockets or photon rockets which we can visualise theoretically now and may put into practice soon. But we cannot yet say how long it will take — whether a manned Moon-landing will be achieved by 1970 as the Americans hope, or within the following decade; whether men will visit Mars and Venus this century or next. Having studied the persistence with which the little creature "man" has made the Earth his own, we can hardly doubt but that he will in due course also make the Solar System his own. No part of it would be habitable in its natural state. But similarly few parts of the Earth's surface would have been habitable to the primitive men with whom we began. Just as our ancestors developed techniques which enable us to live almost anywhere on Earth, so our descendants will develop the new techniques that will allow them to live beyond the Earth. And within a few centuries there may well be human colonies on Mars and Venus or on the satellites of bigger planets – perhaps even colonies living in open space. We must resist the temptation to speculate on the new opportunities and new problems that will face them.

One thing, however, is certain. They will not, within the confines of the Solar System, meet any other intelligent life. But then the Solar System is, as it were, only our own back-yard in space. Our Sun is just a typical member of a family of about 100,000 million stars which we call the Galaxy — a conglomeration of stars in the form of a disc, bulging a bit at the middle, and something like 6,000 million miles across even on our reduced scale! Of course our own Galaxy is just one of millions upon millions of other galaxies, which stretch out to distances a hundred thousand times as great again, and probably much more. But let us be content with our own Galaxy - the city of stars in which our Solar System is just one house and garden. Though we are very far yet from any positive knowledge on the subject, theoretical considerations suggest that a very large number of these stars should have planets providing environments rather like that of the Earth — 600 million of them according to a recent sober estimate — and very probably intelligent life will have evolved there.

What are our chances of visiting these distant planets and getting to know their inhabitants? This is a very much tougher proposition than anything we have considered so far. For the distance to even the nearest star has gone up by a factor of thousands or tens of thousands compared with distances inside the Solar system. Even on our reduced scale, with the Earth 6 inches in diameter, this nearest star would be 300,000 miles away — and so far we've lifted Gar natural state. But similarly few parts of the Earth's surface would have been habitable to the primitive men with whom we began. Just as our ancestors developed techniques which enable us to live almost anywhere on Earth, so our descendants will develop the new techniques that will allow them to live beyond the Earth. And within a few centuries there may well be human colonies on Mars and Venus or on the satellites of bigger planets – perhaps even colonies living in open space. We must resist the temptation to speculate on the new opportunities and new problems that will face them.

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This calculation was made on the assumption that we should be using rockets which, like our present ones, could only have their engines running for a few minutes, and must coast for the rest of the journey. If we could create space ships whose engines would run continuously for years on end, then they would be steadily accelerating all the time; and even with very modest engine power, they would reach such enormous speeds that journeys to other stars would become quite feasible. Such rockets are quite impossible at present. And even if we assume perfectly efficient use of the best energy source we know - namely the building up of hydrogen into helium in a fusion process - and even if we could arrange to re-fuel continuously on the journey by picking up the hydrogen that is scattered between the stars, they would still be quite impossible. But it would only require another step comparable in magnitude to the step from chemical to nuclear energy that has .been taken in the last few decades — and with that, these continuously accelerating rockets would be on the cards. In view of the headlong advance of science nowadays, it would be foolish to deny the possibility of such a discovery within a few decades or centuries. And so the prospects of journeys with continuously accelerating rockets are worth considering.

Let us, then, imagine a journey made in a rocket which has a steady acceleration of 1 g — that is, the same acceleration as a stone falling near ground level. Travelling in such a ship would be comfortable, for one would feel all the time as if ordinary gravity were pulling one towards the tail. For half the outward journey the rocket accelerates; it is then turned round so that the motors act in reverse, decelerating it to a stop at the target point and then accelerating it back towards the Earth; at the half-way mark the rocket is again reversed and decelerates to land at its starting point. With such a vehicle this journey of about 25 million million miles (that is its real distance) to the nearest star and back would take only about seven years and three months — not much worse than a voyage round the world in the time of the first Elizabeth.

But now comes a curious point. That seven and a quarter years is the time taken for the return journey as measured by the traveller. But the people that he left behind on Earth will say that it took him nearly twelve years. Time is not the universal thing, the same for all, that it seems to be in everyday experience. It only appears so to us because we have never had the experience of moving very fast. Time is something that, as it were, each individual carries with him; and when people travel at very high speeds in relation to one another, their individual times will get out of step. In this case the traveller will have reached nine-tenths of the speed of light, and as a result he will have aged less than his friends at home.

Let us consider a much longer journey - right across the Galaxy, coming to a stop on the far side. Even this enormous voyage would only take twenty-two years of the traveller's life. But he need hardly bother to consider making the return trip of forty-four years, for his friends at base will have been dead for 120,000 years when he returns. With this continuously accelerating rocket, if and when it can be built, virtually no part of the universe would be barred. A trip to the farthest galaxies that our radio telescopes can detect would take only forty-five or fifty years (of the traveller's time). And every time one multiplies the distance to be travelled by ten, one only adds four years seven months to the journey time.

It is an exercise in wishful imagination and arithmetic.

CALORIE REQUIREMENT OF A 'YOUNG' POPULATION WITH HIGH BIRTH & DEATH RATES

	Assumed body weights of adults (KG)		Temperature (C)°		Calories/day required by men aged 20/29: Hours/day field work done by men 4			8			Calorie requirements/day/head of total population: Component varying with temperature only — Children under 15	Components varying with temperature and body weight — Woman	Men		Total	
					Hr/day	Cal/hr	Cal/day	Hr/day	Cal/hr	Cal/day			4	8	4	8
FAO estimates	50	40	25				2449				727	447	779		1953	
FAO estimates for African weight	57.5	—	25				2707									
				Field work	4	250	1000	8	250	2000						
				Other active work & recreation (e.g. housebuilding, dancing)	1	250	250	1	250	250						
				Walking	2	184	368	1	184	184						
				Sedentary activities	9	78	702	6	78	468						
				Sleeping	8	62.5	500	8	62.5	500						
Central Africa	57.5	50	25				2820			3402	727	526	897	1084	2150	2337
India, S.E. Asia	50.0	40	25				2545			3070	727	447	811	975	1985	2192
S. China	50.0	40	20				2614			3153	747	459	834	1003	2040	2209
N. China	55.0	45	10				2735			3300	756	528	877	1051	2185	2365

10. AFFLUENT SOCIETY AND LEISURE

Let us examine future world in which people will sing and laugh spontaneously when they go to work, and when they return from work. A world in which there is much happiness for the common man, and much creative struggle for the uncommon man.

For the common man, life is a cycle. It starts with the discovery of the world around the child in which everything is new, it then goes on to the great discoveries of sex and love, and it culminates in the young family. It contains the smaller cycles of work, rest, and recreation, of modest wishes and their fulfilment. It can be a happy life to the end if there is not much physical suffering, and if the old man or woman has learned to love the new generation more than oneself.

U.S. FERTILITY RATES BY OCCUPATION OF HUSBANDS

OCCUPATION GROUP OF HUSBANDS	1952	1957
PROFFESSIONALS	61.0	64.0
PROPREITORS	65.0	69.0
CLERICALS	58.3	63.5
SALES WORKERS	59.0	67.0
CRAFTMEN	71.0	75.5
OPERATIVES	76.0	81.0
SERVICE-WORKERS	66.8	77.0
LABOURS (EXLUDING FARM WORKERS)	88.0	89.0
FARMERS	100.0	100.0

The uncommon man wants to leave a world different from that he found; a better world, enriched by his personal creation. For this he is willing to sacrifice much or all of the happiness that the common man enjoys.

A society composed entirely of the first type of men would be very stable, but dull and stagnant, a society of dedicated world-improvers would be explosive and shortlived. Far be it from us to believe that the common man needs nothing but material comfort, but we must begin with the problem of production. Forty years ago Bertrand and Dora Russell estimated that if all waste and extravagances were cut out, an average of four hours' work per day would be sufficient to produce the goods which at that time were considered as necessary for a 'goodlife'. This estimate still stands as a reasonable one, though the technological progress in the meantime would now allow us to include in the 'good life' many things which were considered as luxuries forty years ago. On the other hand we have not got a single step nearer to cutting out waste. The average hours in industry have dropped in the advanced countries from something like 60 hours per week to about 40, and real income has at least doubled, but the waste in armaments, unnecessary transport, obsolescent goods, and Parkinsonian office work has increased all the time.

Even if one disregards ihe revolutionary changes which may come about by cutting out waste one is driven to the conclusion that the material paradise of the common man cannot be far away. A 'glandular optimist', but highly practical man, Morris Ernst, has made a forecast of production and consumption in the United States in 1976by a cautious extrapolation of the data and trends available in 1955.

According to Ernst, the weekly hours of work in the U.S.A. were

in	1766	1925	1933	1953	
	80	60	47	40	(farmers 52 hours)

from which he concludes that by 1976 the working week will amount to 30 hours (This incidentally, is the same figure at which Thomas More arrived in 1516 - but at a rather different standard of living). Such a straight extrapolation can be of course entirely falsified by the facts. It is true that in 1962 the New York electricians and plumbers obtained an official 25 hour week. This however, means something like 35 hours actual work, the extra 10 hours to be paid at overtime rates. There is very indication that on the way from a 40 hour week to a real 30 hour week there will be a formidable hurdle to take - psychological rather than economic.

By 1976 the gross national product in the U.S.A. can be expected to rise, according to Ernst, and also - to other forecasters, to 700 billion dollars, and the population to 200 million. Personal consumption may reach 500 billion dollars amounting to more than 11,000 dollars per family, about three, times, more than in 1929 at the height of the first great American boom. Lest it might be objected that this will be consumed 'by the rich' the table below gives the percentage trends in the distribution of income in the U.S.A.:

	Wages and Salaries	Entrepreneurs	Dividents	Interest	Rents
1913	57	27	6.4	4.4	5.2
1953	71	20	3.6	2.4	2.4

From this it appears likely that by 1976 the 'workers', even in the narrowest sense of the term, may receive perhaps 80 per cent of the national income, especially if one considers that workers are also shareholders and receivers of interest on their savings.

The United States are of course a unique case, because of their size, their material resources, and the skill and energy of their population. The target figures for the U.S.S.R. in 1980,which Khrushchev presented to the 22nd Party Congress, fall mostly between the present-day figures of the U.S. and their forecast for 1976. These are based on a very much steeper extrapolation, involving an enormous effort and further 'temporary' sacrifices of consumers, for which there is no need in the U.S.A., but the hours of work are about the same. In the European industrial countries the average income per head is now around one-half of the level in the U.S., but the annual increase is steeper, except in Britain. It is not over-optimistic to expect that by 1976 Western Europe may not be much behind the 1955 U.S. level of consumption.

How does the U. S. worker spend his money? Most of it of course goes into food, clothing, housing — primary necessities, though satisfied far above the traditional level — and new 'necessities' such as motor-cars, but some 6 per cent go into recreation. Not surprisingly, a huge industry has grown up in the U.S. to cater for the leisure of the common man. According to Ernst, three and a half billiondollars are spent annually on 'do-it-yourself' tools and materials, of which not less than 150 million are spent on power tools. Many Americans have a real little factory in their homes, and play at work after 'working hours'. A billion per year goes into photography. Billions are spent on pleasure boats, of which there are already 5 million, owned by 17 million people (Ernst quotes an estimate ot 50 million boats by 1976!) At least 3 billion dollars are spent on foreign travel, and not much less on pets. Passive entertainment makes a comparable sum, 1.8 billion on theatres and movies, about twice as much on television and radio. The sale of music records (which was about a quarter of a billion at the time when Ernst made his estimate) has shot up to a billion, a quarter of which is classical music. With this we have reached the fringe of what is traditionally called 'culture'. We find that, in 1954, 45 million dollars were spent on classical music concerts, 5 million more than on baseball, but only 12,000 book titles were published, as compared with 18,000 in Britain (where the 1961 figure was 25,000), and fewer than 150 American authors made a living exclusively from book royalties. Three-quarters of the books were bought by 10 per cent of the population.

Any paradise of the Common Man would be incomplete in which nothing is done to satisfy his need for gambling. This is a subject which is seldom mentioned by philosophers; it has grown empirically. Horse races, dog races. lotteries, premium bonds, the Stock Exchange, all cater for this need. They create a circulation of money in the social body which is economically unnecessary (with the exception of the Stock Exchange), but psychologically indispensable; similar to the Parkinsonian whirl, but far less dangerous. Even the communist countries had to recognize this psychological need by allowing premium bonds and lotteries. It appears that for a great many people life loses much of its interest unless they can hope to get something for nothing - something beyond their deserts!

Barring catastrophies, material prgoress appears assured in the near future in the industrially advanced countries, but it would be bold to assume that it will accelerate at the rate as it has done in the past. It becomes increasingly easier to make a living, more difficult to make a fortune and the young people seem to adapt themselves to this sltuation, though with a visible loss of zest. This process will go on, but it must not be allowed to lead to complete apathy. We shall need a moral equivalent of the economic game, as we shall need a moral equivalent of war. Even discounting those who assert that an industrial civilization stabilized at a high material level is economically impossible, one must admit that there are grave psychological difficulties. Do what you will, stagnation, at whatever level, remains an ugly word to intellectuals who have grown up in an epoch of material progress, except to those few who are longing for a pastoral Arcady which has never existed. Even two terrible world wars were not sufficient to give to people, except to the meek and weak, a longing for a peaceful existence at the price of stagnation.

A more urgent question must be considered first, and this is whether the common man can be happy in a world in which his security is assured, and in which his time is spent between mild work, designed at least as much as occupational therapy as for the production of goods, and healthy recreation. Few people would have doubted this fifty years ago; an affirmative answer would still be considered as self evident in Russia or in China, but grave doubts have arisen in the advanced Western countries.

There are today four million compulsive alcoholics in the United States, tying in rate with Sweden. The rate is highest in the rich West, which by climate and wealth is the nearest thing to an industrial paradise. In lovely San. Francisco one adult male in ten is an alcoholic. In criminality the U.S. have the highest rate of all countries.

In Britain between 1939 and 1961 crimes of violence by the 14-21 age group have increased nearly fifteen-fold. This, writes Anthony Crosland, 'come as a particularly poignant shock to liberals who had traditionally equated crime with poverty and bad housing: the new violence, on the contrary, seemed actually a product of prosperity'.

This would be a high price to pay for prosperity, and it would be terrible if the only cure for it were the return to old times, when the young were broken in early to hard work, cruelly thrashed when they misbehaved, and the drunkard perished miserably in a world which did not know of public assistance. But the conclusion is inescapable, that the education which was good enough in the times of poverty is not good enough in prosperity.

The more permissive the society, the less permissive must be the education which makes the individual fit to ive in it. If the adult is not to abuse his freedom, self discipline must be impressed into the mouldable character of the child or adolescent. Some of the more auccessful of the old privileged classes had a inkling of this; witness the harshness of the old English public schools, or the Spartan upbringing of the Samurai. Those who did not have this instinct, like the French nobles of the ancient regime, perished by violence unless they perished first from boredom.

PARADOX OF THERMO-NUCLEAR AGE

11. SPIRITUAL CRISIS

The philosopher Kant's words are very apt in present paradoxical situation: "Two things fill in my mind with ever increasing wonder and awe, the more often and more tensely the reflection dwells on them: the starry heavens above me and the moral law within me. . . . .. I often brood, sometimes pessimistically, over the question of a link between the apparently chaotic state of affairs prevailing over man's life and the conscience of Mankind." (IMANUEL KANT).

Our present age is allied to a queer paradox - the paradox of the sublimity and humility of human spirit. From the point of view of material advancement, our life today offers a uniquely exalted panorama of hope and prosperity, while on the other hand, dark and grimly horrifying clouds of frustration and defeatism fall over the horizon. The paradox, more elaborately explained, is that of life and death - of man's survival and extinction on the earthly planet.

THE RHYTHM OF CHANGE

"The fundamental fact of today", according to Nehru, "is the outstanding rhythm of change in human life". Says he: "I have seen many astonishing changes during my life time and J am sure that in the course of the next generation even greater changes will take place, if humanity is not overtaken and crushed by an atomic war............ But though man has come to conquer external conditions he has lost, at the same time his moral strength and his ethical power to control his self. He has failed to conquer himself. This is the tragic paradox of this nuclear age."

While on one hand, modern man is torn into fragments by the tyrannical ethos of self-conflict, on the other, he is frightened fatally by the continuously lurking spectre of a nuclear war. As a matter of fact, modern man's external danger is not so alarming or grave as the inner Peril that has crept into his soul. This spiritual bankruptcy of modern man has made him ethically barren and completely destitute of the inner values which make up sum —total of the essence of humanity.

THE COSMOS AND YET DISINTEGRATION

"Humanities are no substitute tor medicine or psychiatry", says a modern Free Thinker, Jacques Barzun. "They will not heal diseased minds or broken hearts, any more than they will foster political democracy or settle international disputes." In fact, the so called humanities have meaning chiefly because of the inhumanity of life; what they depict or discuss is strife and disaster. 'The Iliad' is not about world peace; 'King Lear' is not about a wellrounded man; 'Madam Bovary' is not about the judicious employment of labour time. The humanities, again, are certainly not more human than science. To quote late George Bernard Shaw: "the humanities, too, like science, are a form of knowledge — a misbehavioural science." And this misbehavioural science, according to Shaw, deals not with what is uniform and regular in nature or man but with what is individual and anarchic.

The theme of the modern world, is of its coming closer together and the human society has become something of a 'cosmos'. But our worst trouble is that we have not yet acquired towards the welfare of the whole, the kind of feeling we have towards our own well-being, and there is yet one more trouble with us - to quote the words of Bertrand Russell, "we are beset in our daily life by fret and worry and frustrations." Our minds, as another modern philosopher, L'Zo Mawton believes, have become a pond of stagnant thoughts, where "there flows not a single rippling current". A shrewd scientist or a philosopher, like Huxley, may suggest a scientifically balanced psychological remedy - "brainwashing of modern man with the brush of ethical principles." The question again crops up — as to how thisbrain-wash is to be accomplished and that who is to initiate the adventure?

The atom bomb and its allied engines of mass-destruction, have been a terribly-shocking nightmare for the innocent men and women, awaiting with heavy breath the first exploding of a megaton bomb from a rocket. Human civilization, thus is in a state of perpetually depressing downward- sinking pessimism despite all hopes of the U.N.O. is offering us and the signing of the East-West Nuclear Test Ban Treaty.

The world today faces a gravely stern challenge that assumes a variety of features. There is the material and economic problem arising out of widespread social equalities. Allied with the need of food and raiment :for the body, specially in the underdeveloped countries, there is the necessity of ensuring cultural progress of man. There is, further, the intellectual and spiritual crisis, which lies in the circulation of new- ideas, claiming to be true, ana at the same time, destructive of the old; it lies in the view that nothing is in firm possession of the field and that faith itself needs justification and must secure it if faith is to remain. Moreover, a world that glorifies sex and hates restraint, which identifies purity with coldness and impurity with manliness, innocence with ignorance, and meakness with weakness, is dead to spiritual perception.

THE CAUSE

The root-cause of all this unrest is the fact that the world today is in a state of spiritual and moral bankruptcy. Terror-stricken, the people of the world have had to witness a new immense advancement of the means and arts of destruction, and, at the same time, be spectators of an inner decay, which, through the hardening of the moral sensibility, precipitates the complete suppression of every sentiment of humanity and rushes them towards a darkening of reason and of the spirit. "The giant strides, science has taken in the physical, natural, mathematical and industrial spheres have left in their wake, a proud world bereft of social and moral values, a world forgetful even of the existence of a person God, the Author of every Science !" If this, then, is the ultimate cause of the deplorable condition of the world today, it will avail us nothing to try and heal the prevalent economic and social evils unless we first attend to the root of these troubles - any more than it will profit us to cure an external ulcer leaving untouched the deadly cancer causing it within.

It is only when the great rulers of the world are armed with such spiritual weapons as Charity, Love and Humility that they can arise courageously and confidently to meet the gathering storms. A spiritual approach is the only way to the world out of its present manifold ills, a solution that will first reconstruct the broken relationship between God and man. The great leaders of the world will do well to bear this in mind that when aiming at world peace, and building up their nations according to set economic principles, and joining in Summit Parleys to provide for the safety of their respective countries, they will be wise to remember these lines:-

"Vain is the builder's toil if the house
Is not of the Lord's care:
Vainly the guard keeps watch, if the
City has not the Lord of its guardian."

RADICAL HUMANISM - THE NEED

One thing, and only one, is needed to save our beautiful earthly Paradise from being transformed into a terribly spectacled ever-burning inferno — a radical change in man's outlook on his self, in his attitude to his fellow human beings. Adjustment in the code of human relations and behaviour on the plane of ethical principles must be made to redeem the world of the present spiritual crisis that has darkened the future of human civilization. We have to count in terms of moral and spiritual re-orientation of life and not in those of material and scientific facts alone. Man does not live merely by satisfaction of this material or political needs and requirements. He must satisfy his inner spiritual and moral urges. What we need today is radical humanism, and this is the only beacon that could guide the ship of human destiny through the storm of selffrustration.

Radical humanism, according to Gandhiji, is the greatest sociological truth — a truth which was preached and established by the great masters of the world, like Swami Vivekananda, Tolstoy, John Ruskin and Franklin. This radical socialist humanism, preached by Mahatma Gandhi, demands effective practical action; it involves an obligation to struggle for the achievement of its ideals. "Effective action means co-operation and this requires selfle'ssness and discipline. There are great moral values, and these values are to be rediscovered and re-developed by modern man.

The most dominantly striking impact which our present civilization bears is the latest scientific and technological achievements. 'Science has almost perfected our civilization, having purged it of the stupid superstitions and sordid narrowness, and made it a reality - a nuclear reality. It has enabled our civilization to grow into a cosmic stretch of all - embracing possibilities, making man an all conquering .force. Yet science has miserably ignored its ultimate purpose and looked at stark facts alone. It made the world jump forward into a leap, built up a glittering civilization, opened up innumerable avenues for the growth of knowledge, and added to the power of man, to such an extent that for the first time it was possible to conceive that man could triumph over and shape his physical environment without the aid of nature. Man became almost a geological force, changing the face of the planet-earth chemically, physically and in many other ways. Yet when this sorry scheme of things entirely seemed to be in his grasp, to mould it nearer to the heart's desire, there was some essential lack and some vital element was missing. There was no knowledge of ultimate purposes and not even an understanding of the immediate purpose, for science had for us nothing about any purpose in life. Nor did man, so powerful in his; control of nature, have the power to control himself, and the monster, he had created, ran amuck.

"1 have devoted most of my life to science", says Aldous Huxley. "This has been largely because I am so made intellectually that I want to know all about the things. I cannot help valuing knowledge for its own sake or finding interest and excitement in the pursuit of new knowledge. But I would not continue to devote my energies to science if I did not believe that science was also useful, and indeed, absolutely indispensable to human progress. It is the only means by which man can go on increasing his power over nature and over the destiny of his race. On the other hand, without an adherent of any sect, orthodox or un-orthodox, I have been always deeply interested in peace and believe that religious feeling is one of the most powerful and important of human attributes. So here I do think myself as a representative of science, but want to talk as a human being, who believes that both science and peace are of the utmost values."

A civilization, which is entirely built and supported on science and technology and whose very facets are varnished by the tyrannical ethos of cold war-springing out of the latest mass-destructive scientific inventions - cannot claim to maintain a substantially satisfactory stability. Human civilization, it must be noted, counts for much more in human affairs than politics. According to Swami Vivekananda, "civilization is not a pose of intellect only, nor is it a code of certain conventions; nay it is an inner attitude of life, which finds nothing human alien, common or unclean".

BANKRUPTCY OF SOUL

"The whole of Nature is for the Soul, not the Soul for Nature. The very reason for Nature's existence is education of the soul; it has no other because the Soul must have infinite and ultimate knowledge - and it is through the realisation of this supreme knowledge that the soul achieves its liberation from the material imprisonment", says Swami Vivekananda.

Work is worship — as Carlyle has said aptly. But the "world must not be too much with us!" "We have abandoned our spiritual heritage and auctioned the serenity of our soul", lamented Saint Beauve. Today, the most complicated and complex problem which our Nuclear-architected civilization is facing in a bewildering stun, is the anti-climax of our drama of material pursuit. Work is indeed worship, provided that it has an ethical standard of assessing one's life's purposes and aspirations. "God has been dethroned, His sceptre is being broken and in His place we have enthroned the demon-god of nuclearism."

One more history is about to repeat itself, for today under the fiercely - dazzling light of modern science, when the strong, invulnerable sacred beliefs have been shaken to their very foundations, when the special claims laid by different groups and sects upon the allegiance of mankind have all been blown to atoms - when the sledge-hammer blows of modern antiquarian researches are pulverising when Religion is mocked at and ethical codes of life booed and jeered at — we have to evolve a new pattern of thought to steer the bewildered and dazed vessel of human judgement to the right shore. Our vision, which has been dimmed and paled, must be enkindled into ethical broadness.

Crude theological phantasies of the old have been smashed into fragments by modern man, and in it he certainly deserves a good deal of credit. How beautiful our modern scientific civilization can be if we see the vision of divine beauty in our souls through the aid of science. When the modern tremendous theories of evolution and conservation of energy and so forth are dealing death blows to all sorts of hackneyed and crude theologies, what can hold any more the allegiance of cultured humanity but their most convincing, broadening and ennobling ideas that can only be found in the most marvellous product of the soul of Man — the Wonderful voice of God in His guiding-message to humanity!

12. SPIRITUAL TECHNOLOGISTS

Both the need and the aptitude for technology are rooted deep in human nature.

The goal of all technology, is to make matter serve the human spirit as the most pliant instrument possible for authentic human growth. This involves both the gradual liberation of man from all inhumane, degrading, purely animal-like drudgery and subservience to matter, and also the positive transformation of matter to express man's own spiritual vision of the meaning and purpose of the universe.

On the debit side it must also be admitted that there are grave dangers inherent in the pursuit of technology, as in the use of all natural human aptitudes. These perils arise, it seems to me, from two main sources: first, lack of subordination to the higher spiritual good of man: second, lack of the proper rational control of the rate and timing of technological development.

The danger of the first is that what should be a mere means, at the service of the spiritual growth of mankind, may become so all-absorbing that it will upset the proper hierarchy of values and reduce the spiritual intelligence of man to the role of a mere servant of technological progress pursued for its own sake. Technology would then become like an overdeveloped organ or the runaway growth of cancerous cells - a threat to the basic cultural and spiritual health of mankind.

The second main danger is that the tempo of technological development be allowed to follow unchecked its own inner dynamism, independently of its relation to the balanced over-all good of the people it is supposed to serve, too rapid a tempo of change can produce an atmosphere of such constant flux and severe social dislocation that the people subjected to it will be in grave danger of becoming culturally rootless and deprived of all fixed landmarks as they are whirled hectically along by the racing current of "progress". Thus the even increasing mobility made possible by the automobile (though not so much, strange to say, by the airplane) has so far proved to be a very mixed blessing, whose dissipating effects we have not yet learned to control.

Another form of the same danger is to so-called "enslavement of man to the machine". The harsh rhythms of the machine and its artificial environment will, it is said, dominate or destroy the heathy natural rhythms of the '--" living body in harmony with nature as God made it. The example of the assembly line, with its impoverishment of creative ability and subjection of the workers to a monotonous, repetitive routine, is sufficient warning of where technology can lead.

All of these dangers are real and serious, in addition to the very special and obvious perils connected with the use of the immense power now at our disposal. Uncontrolled technology can certainly bring down disaster, perhaps irreparable, on our race. The only protection against it is a growth in man's spiritual ana moral maturity proportionate to his growth in technical skill and power. Either we grow in both dimensions or We perish, like the overgrown monsters of our prehistoric past. But this is already a law in the development of every individual personality. If individuals can solve it there is no reason why people generally cannot either. Actually, it seems that there is already a rapidly growing recognition on the part of both scientists and political leaders - who are also the ones most able to do something about it - of the urgent necessity of greater moral control over the exploitation of scientific and technological advances.

Furthermore, as technological development proceed along its oourss among a people still endowed with basic biological, social and moral vitality, certain laws of equilibrium and self-correction seem to be constantly and unobtrusively at work. Thus, losses in one area are compensated for by gains in another, or exaggeration in one direction generates its own counterreaction in the other direction. Thus the very mobility which seems, at least temporarily, to be weakening our roots in the family and the local community is at the same time strengthening our bonds with the rest of the world. The very increase in perfection of the means of communication at a distance, as in television, may eventually make it neither necessary or desirable to move about so feverishly on a small scale as we now do. We may end up by visiting our friends and clients relaxedly on a two-way television circuit rather than by transporting ourselves physically to them along over-crowded highways or airways. Or by the mysterious providence of God it may happen that the insistent challenge of outer mobility may succeed more effectively than pulpit sermons in making us turn within and discover that it is possible to achieve a sense of permanence, self-identity and rootedness in more interior, supramaterial and universal values than we now believe capable of winning our allegiance.

What of the threatened enslavement of man to the machine? The danger is real. But we are convinced that it is limited by the very inner logic and laws of equilibrium of technology itself to certain transitory types of techniques and local or temporary abuses during periods of transition. The whole innate drive of technology is to substitute machines for man in all areas where monotonous, repetitive actions are the rule, and to leave man free for more intelligent, creative Or supervisory work. The true danger lies in the moral dispositions of those who use technology. The true danger lies in the moral dispositions of those who use technology. The far greater peril is that men may become slaves to their fellow men rather than to their machines. If we have the courage to assume with full moral and intellectual maturity the responsibility of actively guiding and controlling the mighty power of technology that is now in our hands, far from being ruined by it, we shall be able rather to turn it into a profoundly beneficent instrument for the authentic growth of the human family. And no one has greater inner resources for rising to this chanllege, nor more urgent .motives for doing so, than the spiritually bent Technologists.

13. A WORLD SOCIETY

"Freedom from misery, the greater assurance of finding subsistence, health and fixed employment; an increased share of responsibility ... in security from situations that do violence to their dignity as men: better education – in brief, to seek to do more, know more and have more in order to be more: that is what men aspire to now.

The younger or weaker nations ask to assume their active part in the construction of a better world, one which shows deeper respect for the rights and the vocation of the individual.

Excessive economic, social and cultural inequalities among peoples arouse tensions and conflicts, and area danger to peace. Peace cannot be limited to a mere absence of war, the result of an ever precarious balance of forces. No, peace is something - that is built up day after day, in the pursuit of an order intended by God, which implies a more perfect form of justice among men.

AN END TO ISOLATION

The peoples themselves have the prime responsibility to work for their own development. But they will not bring this about in isolation. Regional agreements among weak nations for mutual support, understandings of wider scope entered into for their help, more far-reaching agreements to establish programmes for closer co-operation among groups of nations — these are the milestones on the road to development that leads to peace.

NEED FOR A WORLD SOCIETY OF TECHNOLOGISTS

This international 'collaboration on a world-wide scale requires institutions that will prepare, co-ordinate and direct it, until finally there is established an order' of justice which is universally recognized.

Some would consider such hopes Utopian. It may be that these persons are not realistic enough, and that they have perceived, the. dynamism of a world — a world which, in spite of its ignorance, its mistakes and even its sins, its relapses into barbarism and its wanderings far from the road of salvation, is, even unawares, taking slow but sure steps towards its Creator. This road towards a greater humanity requires effort and sacrifice, and suffering, accepted for the love of our brethren.

14. TOWARDS A CLASSLESS SOCIETY?

Our question as to. whether the disappearance of classdivisions is also a necessary step if our Technological Revolution is to lead to abundance far all — is a much more controversial one, and there will (as yet) be no general agreement an the answer. Fundamentally the question is not concerned with the equalisation of personal incomes, but rather, with the ownership and control of the factories, mines, railways, ships and other means of production. The paint at issue is whether these shall be the property of the community as a whole (as they were in primitive societies and are in the socialist countries of today), or shall be owned and controlled by some privileged class as they have been in all societies from the beginning of civilisation down to the capitalist economies that still cover two-thirds of the world. And since all ather systems are now clearly aut of the running, the choice reduces to one between capitalism and socialism.

Which of these .can make a better job of using modern technological advances to create a world of plenty? Surely the evidence surveyed, suggests that the answer is socialism. it would be tedious to recapitulate the features of capitalist society Which we find to. be acting as brakes on progress, unemployment, vested interests etc. We have witnessed that the socialist countries, though most of them started from; very backward industrial situation, have already taken over the technological leadership in several fields. And the statistical survey shows that they are doing much better than their capitalist counterparts in using science and technology to make a wealthier world.

Furthermore, capitalism seems to have reached a limit in the speed at which it can advance — for Britain in recent years shows rates of expansion on only a little higher than those achieved by the capitalist world between 1920 and 1938, while the U.S.A., though certainly bettering those very lean years, can only just equal the progress that capitalism was achieving between 1860 and 1913. It appears that capitalism can expand its economy no faster than it has been doing. And one can be doubtful whether even this rate can be maintained — if, for example, the rate of automation in America causes unemployment to increase in the way we discussed, there must come a point, at which either the introduction of automation will be slowed down or some drastic break will occur. But, while the capitalist economies seem to be at or near their limits, the socialist countries continue to expand their industries two or three times as fast.

Then, there is a case for the thesis that we are today in one of those periods in which the advance of technology has outstripped social development, and that in order to permit further progress to go on unhindered, it is now necessary to make big political and social changes — namely, to complete the transition from capitalism to socialism that has already taken place in a third of the world.

ON THE WAY TO THE WORLD OF PLENTY

We begin to get some idea at this point of what is meant by saying that the Second Technological Revolution is capable of bringing us rapidly to a state of universal plenty. But before we pursue this subject, let us look at a more sobering side of the picture. In India the national income per head on 1962 was about £24. If it has been growing at the Soviet rate since 1953, it would have been £36 — which may be 50 per cent better, but is hardly high enough to be encouraging. Even at this speed it would be very many years before India (and all the other under developedcountries of which she is typical) came within sight of the land of plenty. And in the world of today, unified by the very technological advances we are considering, it is surely meaningless to consider the possibility of achieving riches in a few advanced countries, while others remain abjectly poor. The antagonisms created by the envy of the have nots would be certain to lead to confiicts that would (at the very least) retard progress all round.

The problem of the underdeveloped countries is, of course, to find means of providing capital investments so great that they can catch up with Europe and North America within a reasonably short space of item. And evidently out of a national income of £24 per head (for India is typical), this cannot be done. It is clear that the advanced countries must help the less fortunate with loans and gifts. And indeed they do so, but on a scale that is far too small to solve the problem. On the other hand, it has been calculated that if one-third of what the world at present spends on war and war preparations were given instead to te under-developed countries — in the form of new factories and equipment, scientific and technical advice, new schools and colleges and the staff to get them going, and all the other essentials of industrial civilisation — then their progress could be so speeded up that it would only be a few decades before all the world reached a standard of living comparable to that of Western Europe today. To the people of Africa, South America and Southern Asia this would indeed seem to be a world of plenty.

It is naturally not possible to assess accurately how fast the world could grow rich, if all the artificial restraints imposed by inadequate social organisation were removed. But many lines of approximate calculation converge to suggest that at the very least it would now be possible to double the output of wealth per head, would be multiplied by 4 in 20 years, by 8 in 30 years, by 16 in 40 years. Would a country in which everybody was sixteen times rich as he is in Britain today be a land of plenty? Each individual (not each earner) would have an income for personal use of between £4,000 and £5,000 a year-getting on towards £20,000 a year for each family. Many rich people in U.S.A. demand things that even such an income could not buy, but surely their diamonds, mink coats and private swimming pools are not things that people really want, but status symbols used to display the fact that they are more prosperous than others. This level or something like it would indeed be universal plenty. If the reader disagrees, he may choose his own figure. Would sixty-four times the present level be enough? Then it would take sixty years to achieve. If one insists on a thousand-fold increase (with personal income per head approaching £ 300,000 a year!), even that would only take a century.

Such a rich world would have no use for either war or class-division. These are merely bad habits (as it were) which arose in the special situation of the last few thousand years, when the partial wealth of the world made them profitable to some. Contrary to what those who have a vested interest in the status quo would have us believe, the desire to dominate others is not an inherent human characteristic. It was not shared by the men and women of the Old Stone Age. It was not found among primitive peoples who survived unaffected by civilisation down to the early years of this century. It appears to be gradually dying out in the socialist countries of today. Trying to benefit oneself at the expense of others is merely a mode of behaviour that has arisen in the exceptional conditions of the last few millennia during which mankind has been passing from the state of general poverty to that of universal wealth. When abundance is available for all, there will be no incentive to dominate others, to seek one's own good at the cost of others' loss. And so, in the world of plenty of the not very distant future, these degrading rivalries will completely vanish.

But the dilemma of our time is that the customs and institutions of class-division and war are the very things that are preventing us from rapidly moving on into the Golden Age of abundance. While we still have not quite enough wealth available to give a sufficiency to all, there are those who benefit from class-division and even, let it be said, from war. They will not voluntarily surrender their privileges. And they command the power to resist change, whether by force or by persuasion through the mass media of propaganda. These resistances have to be overcome before the world of plenty can be attained. But when it has been attained, class-division and war will be so obviously useless that they will never recur.

And what will life be like in this future that some of us may live to see? It is unlikely that we shall want to take our increased wealth in the form simply of more material goods and services. Rather than multiply their material riches by sixteen (let us say), people would probably prefer to have twice or four times as much, and to reduce their working week to 10 hours or 5 hours, and so have more leisure to enjoy. But indeed the distinction between work and leisure will presumably disappear. With ample power, automation and computers - and all the new developments that are to come - available to work for us, the task of providing material goods and services will occupy a small part of each person's life. The rest of his time will not be spent in aimless amusement, but people will discover how to occupy themselves together in companionship, in joyful adventure - in space exploration or scientific research, in poetry or music, or in other creative activities which we primitive people of today cannot yet visualise. Naturally ample wealth will not solve all the difficulties of the future, for people will have to learn new ways of living to make the best use of their new conditions. But the universal plenty will give men for the first time the opportunity to tackle the really important problems, instead of having to devote their energies to scraping a living from nature or quarrelling and fighting among themselves about the sharing of the little that is available.

This is the uniqueness of our time: the prospect that the really constructive and creative period of human history is about to begin - provided we learn the lessons of earlier history and do those things that must be done to bring us quickly to a state of plenty.

What we know of science tells us that there can be no end to discovery and hence to the extension of man's control over nature. But it is unlikely that men will want to use this power to multiply their material wealth for more than another century or so. After that they may well decide that they are rich enough, and that they are better purposes for which they can use their knowledge and their mastery over the universe. In that sense, at least, our Technological Revolution will draw to an end.

15. FUTURE OF CIVILIZATION

Civilization is within ourselves, in our moral conceptions, religious ideas, and social outlook. We cannot call ourselves civilized simply because we use the steamship and the railway, the telephone and the typewriter. A monkey trained to ride a bicycle, drink a glass, and smoke a pipe is still a monkey. Technical efficiency has little to do with moral development. Though the achievements in exact science and mechanical organization of Ancient India or Greece or Medieval Italy are immensely inferior to ours, it cannot be denied that they had a truer perception of spiritual values and the art of life. If civilization is not to be confused with a feverish thirst for new things or a mad race for wealth, there are many salutary lessons in the art of liviing which we can learn from India or China or Ancient Greece. Not that the latter had not their own defects. The leisure and enlightenment of the citizen-body in Greece was made possible by the exclusion from this privilege of the large body of artisans and slaves who followed the necessary but laborious pursuits of the community. Though the Hindu civilization by her wise toleration of local customs and beliefs gradually absorbed the indigenous races of the country into a free and organic synthesis, it neglected the education of the backward people. Hinduideals, however admirable, did not penetrate the mass of the people. In later times there was a sad falling away from the high ideals consequent on the stunting of free manhood under autocratic rule.

Modern civilization is in the stage of economic barbarism. It is concerned more with the world and its power than with the soul and its perfection. It asks us to make the best of the business in hand, for first and final principles are beyond our ken. We have the assertion of mind over life and matter and not yet of spirit over mind, life, and body. To control life and body we have understood their processes and possibilities. In the first triumphs of scientific progress it tended to cast aside philosophy, despise thought, and almost succeeded in slaying religion. Though we are more learned and scientific than our - ancestors, we cannot say that we are less brutal and more humane. Our education has not freed us from intellectual boundage. It stimulates the mind without satisfying it. Economics is our religion. We wage wars to increase our trade, extend our territories and acquire colonies. For the sake of business and markets, we sacrifice our intellectual freedom, as it may impair our efficiency in the exploitation of labouring-classes and government of backward races. Our civilization is a conquering one, based on the rivalries of indivduals and races.

The mechanical virtues of speed, quantity, standardization, and absorption in things material have resulted in a spiritual hardening. Weare suffering from an inner lack of unity and general mental anarchy. A spiritual ideal of a truly human life of freedom and beauty, love and virtue, is professed along with an unintelligent attachment to the life of the body, its vital needs and impulses, a low mental life of sense and emotions, and grossly utilitarian code of practice.

The present era of plenty should end in idealism as I defined in Geeta ?

ऐश्वर्यस्य समग्रस्य धर्मस्य यशसः श्रियः ।
ज्ञानवैराग्ययोश्चैव षण्णां भग इतीरणा ॥

भगवद्गीता अ. ३.२३ (Geeta Rahasya)

16. KALIDASA'S WAY OF LIFE

It will be interesting at this stage to glance at our past civilization and to examine the classical way of life of our ancient civilization as ennunciated by Kalidas in his plays, in Raghuvansha. In Raghuvansha Kalidas describes how in life of King Dilip, Artha, Kama, and Dharma were harmoniously synthesized.

अप्यर्थकामौ तस्यास्तां धर्म एव मनीषिणः ।।

रघुवंशम्

Kalidas emphasizes that progress of the society and security thereof is in no way conflict between religion and morality. He maintains that neither of these are hostile to each other but are complimentary and inter-dependent for the harmonious way of life. This is a natural but a moral phenomenan resulting in temporal success and harmony, Its essense lies in the spiritual strain throughout once life. We must comprehend the inward moral dynamism so that men's ethical will result in liberty and creativity of the human mind.

Kings of the Raghu race pure in birth as they were ruled over vast stretches of earth. They amassed riches for the sake of charity, spoke measured words for the sake of truth, were eager for victory for the sake of glory and reared their family for continuation of civilization. They gained knowledge in childhood, enjoyed pleasures of life in youth, adopted ascetic life in old age and in the end cast away their bodies after Yoga and Meditation. Discipline

त्यागाय संभृतार्थानां सत्याय मितभाषिणाम् ।
यशसे विजिगीषूणां प्रजायै गृहमेधिनाम् ।।
शैशवेऽभ्यस्तविद्यानां यौवने विषयैषिणाम् ।
वार्धक्ये मुनिवृत्तीनां योगेनान्ते तनुत्यजाम् ।।

रघुवंशम्

was essential for a decent human life. The Laws of Dharma were not static but progressive as per needs of the society and technology. We are not inheriters of the past, but also trustees of the future, and one should perform his duties in the best interest of the individual and the society. This brings us to the Karma Yoga of Bhakawat Gita.

Lokmanya Tilak, in his Geeta Rahasya explains the duties of human beings in the society saying that knowing the unity of truth of the knowldge of the universe and self once should keep our mind and intellect detached, serene, balanced and unenvious, one should not ignore our common or ignorant brethren, and without discarding our cardinal duties should live a full life, moulding it to the circumstances of the time and the country, and continue to undertake and execute duties without expectation so that one contributes to the progress of our fellowmen and hence the Society.

It is also pertinent to mention the advice of the Dhutarashtra in Mahabharat *Mahabharat Adi Parva 115.36 and Sabha Parva 61.11

त्यजेदेकं कुलस्यार्थे ग्रामस्यार्थे कुलं त्यजेत् ।
ग्रामं जनपदस्यार्थे आत्मार्थे पृथिवीं त्यजेत् ।।

महाभारत
आः प ११५.३६

For the welfare of the family, one individual should be sacrificed; a family for the village; a village for the entire community i.e. nation and the whole world for the uplift of one's soul.

17. CONCLUSION

Having taken you through the panorama of the projected future resulting from technological upheaval more in the West than in the East, one is flabbergasted with its enormity, unpredictable implications and the resulting complications in the well being of the society. Results of the present technology are awfully evident in the delinquency in some parts of the world. One is sorry to find its reflected adverse effects in the underdeveloped countries in the East. The social upheavals are in evidence everywhere. Although the advantages of the affluent society in the western countries are not available in the underdeveloped countries the disadvantages of human values are seen and are apparent more forcefully in the East. Fortunately the East and especially India has still its moral and spirtiual fabric still in tact. How long it will remain so from the onslaught of technology is anybody's guess. It is, therefore, the paramount duty of the technologists and scientists to see that this spiritual and moral fabric is retained by acquiring leadership in the society. The politicians are taking undue advantage of the technology and viciating the results of technological progress. It is therefore the duty of the technologists to curb the violent, the fissiparous and disintegrating tendencies generated by political ideologies, so that the humanity is served to the better purpose by the fission or fusion of atoms, the mutations of genetic code or space travel. Technologists should take a lead to form a classless and universal society of which the initiatives and leadership should be in the hands of great minds, eminent technologists and engineering fraternity who can bring to bear their unbiased, selfless and balanced point of view on epoch making decisions for the bettermend of the mankind, contributing to its happiness.

Let us pray:

सर्वेसर्वे सुखिनः सन्तु सर्वे सन्तु निरामयाः ।
भद्राणि पश्यन्तु न कश्चिद् दुःख भाग्भवेत् ।।

18. APPENDIX

POSITIVE SIDE OF THE IMAGE OF THE SCIENTIST

He is a very intelligent man a genius or almost a genius. He has long years of expensive training - in high school, college, or technical school, or perhaps even beyond - during which he studied very hard. He is interested in his work and takes it seriously. He is careful, patient, devoted, courageous, open minded. He knows his subject. He records his experiments carefully, does not jump to conclusions, and stands up for his ideas even when attacked. He works for long hours in the laboratory, sometimes day and night, going without food and sleep. He is prepared to work for years without getting results and face the possibility of failure without discouragement; he will try again. He wants to know the answer. One day he may straighten up and shout: "I've found it! I've found it!"

He is a dedicated man who works not for money or fame or self glory, but - like Madam Curie, Einstein, Oppenheimer, Salk - for the benefit of mankind and the welfare of his country. Through his work people will be healthier and live longer, they will have new and better products to make like easier and pleasanter at home, and our country will be protected from enemies abroad. He will soon make possible travel to outer space.

The scientist is a truly wonderful man. Where would we be without him? The future rests on his shoulders.

NEGATIVE SIDE OF THE IMAGE OF THE SCIENTIST

The scientist is a brain. He spends his days indoors, sitting in a laboratory, puring things from one test tube into another. He work is uninteresting, dull, monotonous, tedious, time consuming, and, though he works for years, he may see no results or may fail, and he is likely to receive neither adequate reconpense nor recognition. He may live in a cold-water flat; his laboratory may be dingy.

If he works by himself, he is alone and has heavy expenses. If he works for a big company, he has to do as he is told, and his discoveries must be turned over to the company and may not be used; he is just a cog in a machine. If he works for the government, he has to keep dangerous secrets; he is endangered by what he does and by constant surveillance and by continual investigations. If he loses touch with people, he may lose the public's confidence – as did Oppenheimer. If he works for money or self-glory he may take credit for the work of others as some tried to do to Salk. He may even sell secrets to the enemy .

His work may be dangerous. Chemicals may explode. He may be hurt by radiation, or may die. If he does medical research, he may bring home disease, or may use himself as a guinea pig, or may even accidentally kill someone.

He may not believe in God or may lose his religion. His belief that man is descended from animals is disgusting.

He is a brain; he is so involved in his work that he doesn't know what is going on in the world. He has no other interests and neglects his body for his mind. He can only talk, eat, breathe, and sleep science.

He neglects his family - pays no attention to his wife, never plays with his children. He has no social life, no other intellectual interest, no hobbies or relaxations. He bores his wife, his children and their friends - for he has no friends of his own or knows only other scientists with incessant talk that no one can understand; or else he pays no attention or has secrets he cannot share. He is never home. He is always reading a book. He brings home work and also bugs and creepy things. He is always running off to his laboratory. He may force his children to become scientists also.

A scientist should not marry. No one wants to be such a scientist or to marry him.

'TRILEMMA OF TECHNOLOGY'

By

J. G. BODHE

INSTITUTION OF ENGINEERS (INDIA)

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Technological Affluence and the Quality of Life

Dr S Bhagavantam

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I consider it a privilege to have been invited to deliver this lecture in honour of Shri Nidhu Bhusan Chatterjee. The charter for this memorial lecture specifies that it should deal with a subject allied to science, philosophy and spiritualism. It is an interesting charter. It is somewhat are that these seemingly diverse disciplines coexist in an individual at a point of time, although it is not uncommon that one gets involved in them in succession and at different periods of one's life and one's career. Against such a background and keeping in mind the fact that many distinguished engineers are likely o be present at this Annual Convention of the Institution of Engineers (India), I have chosen 'Technological Affluence and the Quality of Life' as the title of my lecture.

Technological affluence is closely related to industrial growth. Industrial growth carries with it many economic advantages. These aspects of a nation are capable of being measured in cash terms. For instance, the gross national product (GNP) and the rate at which it is growing in regard to anyone nation are fairly good indices of that nation's technological affluence. Such parameters can be worked out by a competent accountant, critically apprised by a trained economist and meaningfully put across to an understanding citizen. To this extent, technological affluence as reflected by our industrial growth is a tangible feature of the society. Per contra, the quality of life is a cultural and sometimes even an ethical issue. It cannot be measured in cash terms and intangible factors like belief and conscience come into the picture when one attempts an assessment thereof. Competence amongst persons claiming to make such an assessment is not so readily found as in the case of those engaged in estimating economic factors such as the GNP, and so on. In fact, considerable experience accumulated over generations of traditional living is required even to make qualitatively valid statements in regard to what we understand by the words 'Quality of Life'. Thus, two concepts are contained in the title of my lecture, one of them measurable in terms of well understood units and the other not easily expressed in so clear a manner but can certainly be experienced by those who have a feel for values. The former is like the emoluments of an individual and the latter is like the happiness he derives out of his life. Very often, there is no obvious correlation between the two.

Technology has, in a superficial sense, furnished us with many gadgets and a variety of appliances. No one can deny. the usefulness of the gadgets or the comfort which they provide. No one can deny the efficiency that we derive in conducting our daily routine with the help of the several appliances that have been produced, but the side effects in some cases are beginning to look extremely worrying. For instance, if one seeks to find a solution for the population problem by advocating the use of the pill, one is in constant dread of some yet unforeseen side effects taking hold of the user and thus creating a new problem. Taking yet another illustration, if we race against time and take recourse to frequent jet travel, our biological clock is sure to get completely upset even if we manage to keep our digestion in tact. A facility like the closed television today enables one to increase the tempo of one's work if one adopts the method of holding conference with one's colleagues at a distance but this will, sooner than later, carry with it the obligation to use heavy doses of a tranquilizer.

The United States of America is at the present time the technologically most affluent nation and yet, ironically enough, it has developed and alarming awareness of the need to watch out on the quality of life which its citizens are acquiring. There are some who fear the danger of things happening in this regard before people are made aware of what is happening. Such a fear has its origin in the fact that while economic growth is a quantifiable aspect of life and more easily or readily understood by the common man, the quality of life on the other hand is a less tangible aspect of social conditions with features that can be appreciated only by the trained critic, a situation which makes the latter more vulnerable to distortion by propaganda put out on behalf of vested interests. For instance, it has been quite easy to convince people that science and technology are the musts of modern economy and that they can be the great deliverers of all under-undeveloped and developing countries from drudgery and hunger. No one can hold out the promise of a golden age today, without insisting on adequate resources being put into modernizing a nation's output with the help of technology. Engineers who have devoted their lives to many different disciplines know this to be an incontrovertible statement. The position is different with regard to quality of life. It required a few decades of actual living in such a high level of technological affluence for the now advanced countries to realise that there are side effects which had eroded into the fabric of life enjoyed by their citizens — the abuse of countryside in which we live, the pollution of the very air we breathe, a possible radioactive contamination of the very water we drink, the high level of nervous teusion in which we work, the constant fear of mutual annihilation by the deployment of weapons of mass destruction in case of war, being some aspects of the all too familiar picture co-existing alongside the currently affluent economy.

Such a deterioration in the quality of life of a nation can come in many ways. I am one who will strongly support economic growth as a prerequisite for improving quality of life but will not advocate this in an unqualified or a superficial manner. To make my point clear, I wish to quote from a recent description, by a noted U.S. economist, of the state of economy of that country.

> 'Economists have misled themselves and the nation by relying on a functionally undifferentiated measure of economic growth. Thus the rise of G.N.P. From $503 billion in 1960 to $932 billion in 1968 does not distinguish between growth that is economically productive and the growth that is parasitic.' Productive growth includes goods and services that form part of the level of living, or that can be used for further production. By this economic-functional criterion, apart from other ya:dsticks, goods and services that are not part of the level of living or cannot be used for further production are economically parasitic.'

> 'By July 1969, while President Nixon was hailing the lunar landing as the greatest work since the Creation, New York City was suffering a combined breakdown in central power supply, the telephone system and railroad transportation. Reliable power, communication and transportation are the key elements of the infrastructure required for an industrial society. Accordingly, the largest city of the richest nation on earth displayed the main aspects of an underdeveloped economy.'

One other factor which may contribute to such a deterioration is the excessive importance that a group of people may attach to material wealth at the expense of other kinds of well being. The growing challenge, particularly from the younger generation, to the established concepts of opulent nations is only a manifestation of this truth. Unfortunately, it is an inescapable fact that when we grow roses, we grow thorns as well. Every new discovery of modern science and technology has been ambivalent. While, for instance, the discovery of Archimedes principle or of Newton's laws of motion during the early stages of scientific development stood on a different footing, the more recent ones such as nuclear fission or laser action have caused us great concern by the tremendous potential which they created both for good and for evil. Hence the heed for safeguarding, more zealously than ever, the quality of life and the ethical principles that go to preserve it, while we press technology into the service of mankind in an attempt to raise our standards of living. I can take an illustration, with a view to explain how ambivalent technological developments of recent times have been, from an almost infinite number of examples that are available but let me spend a few minutes on what are called chemical agents, I shall commence by mentioning a chemical by name phosgene. Since it is amongst the milder of the so called chemical warfare agents, it is classified as a choking gas but even so, was responsible for 80 percent of the deaths caused by gas in the First World War. Phosgene is, however, currently produced in a number of countries. There are countries in which the annual production is of the order of 100,000 tonnes. It is widely used as raw material in the manufacture of synthetic plastics, insecticides, paints and pharmaceuticals. There is another lethal agent by name hydrogen cyanide. It is classified as a blood gas and was also developed during the First World War. Hydrogen cyanide is, however, a valuable intermediate stage in the manufacture of many organic chemicals and dye-stuffs. Hydrogen cyanide is currently produced on a large scale in the United States, several countries in Europe, Japan, the U.S.S.R. and China, total annual production being in the neighbourhood of one million tons. The two chemicals just named are of the First World War vintage and considered very mild in comparison with the more recently discovered ones such as the nerve gases. Nerve gases are organophosphorus compounds, very similar to some commercial pesticides widely used in agriculture. The total world output of the organophosphorus pesticides is estimated to be around 130,000 tonnes a year, the United States alone accounting for about 65,000 tonnes, produced by 14 different manufacturers. I have refrained from' giving figures about agents which are even mor .deadly such as the Botulinum toxin which is one of the most poisonous substances known to science. What is specially noteworthy is that the capacity for producing such deadly chemical warfare agents is linked up and to some extent synonymous with the status of the commercial chemical industry of a country. How do we then distinguish evil from good or assure ourselves a quality of life and a safe world to live in while building up an industrially prosperous world and enjoying a higher standard of living by drawing upon the gifts which the technological monster can confer on us?

The idea that scientific knowledge is a useful power having had its origins in the two world wars has in recent decades been transformed in some degree into the idea that scientific knowledge is a dangerous power. The frightening implications of nuclear weapons, accumulated to an overkill capacity in the arsenals of the world powers, live with us. A possible disaster, if chemical or biological agents get to be used in warfare, hangs over our heads. The potential implications of genetic manipulation cause us great concern and man seems to be on the threshold of acquiring such a capacity. In all this confusion, questions such as what really constitutes progress and how it is different from growth; whether scientific knowledge per se is dangerous or whether the application thereof to satisfy man's lust and greed is the real danger and so on continue to occupy our minds and rightly so.

What is the position of our country in all this. The people of India are poor. The per capita income increased being Rs. 248 a year in 1948 to being Rs. 297 a year in 1957, a period of two decades. We have a large population, about 550 millions at the present time and we are adding to this figure another 13 millions each year. The latter figure is about the entire population of a vast country like Australia. Many of our people go hungry or are undernourished, ill clothed and poorly educated. What is the solution. The only solution that one can foresee has to have its base in modern technology and has to draw on all that it can do to promote our economic growth, to arrest the population expansion and to make the benefits available more evenly amongst the people than at present. The scientists, technologists and engineers have to play their part but in doing so, they should learn from the mistakes of other already opulent nations. We should, in the process, stick to our ideals and our traditions steadfastly and remember that means are as important as the objectives. The philosophy of life, which Indians had accepted through ages, always denounced accumulation of large personal wealth and its utilization for personal aggrandisement. Today, we have given up traditional methods of moving towards a socialistic pattern and have not replaced them with new ones. Alas! 95 percent of our population die prematurely because they have not enough to eat and the other five percent also die prematurely because they have so much to, eat and they over-eat.

At the commencement of this memorial lecture, I stated in a lighter vein that science, philosophy and spiritualism do not generally co-exist at a point of time in an individual. Be that as it may, it now appears almost a truism that we have to strive and get them to co-exist in the life of a nation, if we want to enjoy the fruits of technology and yet maintain the quality of life. I believe that the Indian outlook on life and the generally accepted Indian traditions in regard to moderation and, devotion to duty but with detachment, place India in a position of vantage it we really wish to achieve such a synthesis. I recall that our late Prime Minister Jawaharlal Nehru used to state that what India needs is modern science and technological development tempered with a spiritual outlook. Technological development will surely take us up and up the ladder of material prosperity but when we reach the summits tliereof we will need to balance our thinking by toning it up with a human outlook, so that we do not feel giddy and fall down into depths of barbarity.

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The Engineering & Social Responsibility

Dr P K Kelkar

Although, engineering has been as old as humanity it is only Trom the eighteenth century onwards that it started growing and today it has succeeded in transforming the entire social fabric on a world scale. India has an ancient civilization but its paricipation in the technological growth has been marginal and comparatively recent. The role that the engineer played in Indian society in the past was essentially a subsidiary one. The vitality of the Indian civilization which has made it survive till today unlike so many other highly developed civilizations, derived its sustenance more from a social structure based on metaphysics which identified the main purpose of existence as enlightenment. The consequence of this was that the life of the people as a whole was organized on the basis of caste system, a host of rituals, codified duties and obligations. Pursuit of true knowledge was given priority over acquisition of useful knowledge, thus inhibiting the scientific and practical attitude of mind towards nature and man's environment. Pursuit of happiness as we understand today through material transformation, energy, goods an explotion of nature and natural resources did not form an important part of social development in traditional India.

The machine is symbolic of the contribution of the engineer and in India, social conditions did not encourage the growth of machine civilization. The most interesting point is that the waging of war and defence have provided the most powerful support for the growth of engineering. It is in this context that India had to pay a very heavy price during the last several centuries. Economic growth, industrial growth, urbanization, national consciousness in relation to war and defence are the various facets, where engineering contribution had the most profound influence on the structuring of a modern sticiety.

An important feature of our times is the drive towards uniformity which engineering and technology imposes on every country, Pattern of travel, communication systems, medicine, consumer goods - all these have a similarity all over the world. Mass-production and mass-consumption impose a kind of sameness from which few can escape. As consumers, there is no difference between one individual and another irrespective of the ceuntry of origin. For the first time in human history it seems possible, through engineering and technology, to provide a reasonable material standard for every body. This seems to have become the basic objective of our national effort. The, rising tide of expectations generated in the minds of people because of this, constitutes, the most fundamental social challenge to engineering. It looks as though the scientist, the engineer and the advertiser have between them succeeded in creating 'one world' consisting of consumers.

The American approach to consumption has brought into sharp focus the conflicts between the natural order and the technological order. The rate at which natural resources are being depleted the emergence of transport, housing and disposal problems created by affluence, all these indicate that open ended approach to economic growth and productivity may face serious obstacles. From India's point of view in terms its productivity there seems to be no hope at all of reaching anything like the consumption pattern of the advanced countries. This is so, because of the limitation imposed by the availability of natural resources this planets.

India which has a tradition of encouraging genuine non attachment has a fundamental dilemma which it has to face. It has to define afresh what it means by a genuine standard of living. Pursuit of happiness through economic equality will have judged by economic indicaters and the majority of people will have to be treated as consumers. This releases forces which make the society acquisitive as also competitive, thus, making it difficult to minimise the importance of economic considerations from the most of organized activity. It becomes obvious that 'standard of life' unrelated to 'quality of life' falls to give meaning to life. The professional competence of the engineers depends on logic and reason. His contribution to the society, therefore has to be related not only to econcmic considerations, but other considerations which may generate and Eustain those qualities of personal and collective behaviour, by which it will be possible for individuals to live not only in harmony with each other and with nature but above all with themselves.

The history of India is full of instances of the powerful influence on the minds of people of ethical, moral or spiritual values, although they had no direct bearing on the material benefit they could bring. The modern idea of progress in time is somewhat alien to the Indian tradition of giving purpose to life in relation to timelessness. Each individual has to resch salvation through his own efforts which are unique to himself. That is why as a part of the traditional requirement, conditions were always such as would ensure the supply of the minimum number of enlightened and liberated individuals, so that the society as a whole could be preserved from decay and the vision kept undimmed.

The engineer, therefore, has to be awar that human beings consist not only of the physical self but also the spirit. Whichever way one looks at the problem, as a fact of experience one has to acknowledge that the road to happiness is from the inside out, through physical well-being, through awareness, through a change in one's attitude towards the world. It is in this aspect which ought to have a bearing on our present attempts to briug about a quick and complete technological transformation in India.

India is waging a major struggle against poverty and ignorance. Engineering and science are the instruments of overcoming poverty and ignorance arising out of lack of possessions and opportunities. Indian tradition in the past has shown the way of overcoming poverty implicit in the largeness of desires and of achieving enlightenment which leads to compassion and undarstanding which are essentially products of total awareness. It is in this context that the engineer of today has to discharge his social responsibility.

Nidhu Bhushan Lecture 1973

Shri N G K Murthy

1. At the outset let me acknowledge how greatly I feel honoured by the Institution of Engineers in calling upon me to deliver the Nidhubushan memorial lecture to-day.

2. I thank your Secretary for the kind words of introduction.

3. You will have noted already that I had never been in the teaching profession, like the illustrious previous speakers who gave you the. Nidhubushan memorial lectures, such as Prof. Govinda Rao. Prof. Roy, Prof. Bhagawantarn and Dr. Kelkar. Professionally we speak through drawings and design calculations. I share the handicap of the profession in public speaking.

4. Secondly no scripts of previous speakers are available for reference and guidance. It is then that I realised what I have let myself into, in accepting the invitation when it was extended to me by my esteemed friends Sri Bodhe and Dr. Yiswesvarayya. The attraction to my alma mater overpowered any discretion I may have had. Kalidasa's expression in Raghu Vamsa, describes how ill equipped I felt

Titurshuh Dustaram Mohat
Udupenasmi Sagararn

5. Nidubushan lectures are to be on a subject related to Science, philosophy & spiritualism. An odd mixture is not inadmissible. Be that as it may, I have chosen to speak to you about "water in our lives and water for India's survival & prosperity"

Mythology

6. The fountain head of our philosophy & spritualism is embodied in the Gita about which Warren Hastings wrote prophetically in an introduction to its English Translation by Sir Charles Wilkins.

"When the British Empire is lost in oblivion, when its sources of wealth and prosperity are not remembered, this scripture and the lessons it contains, will continue to inspire millions of people in this world".

Lord Krishna says therein

"Annath Bhawati Bhutani
Parjanyat Anna Sambhavah
Yagnat Bhawati Parjanyo
Yagnah Karma Samudbhavah

Life is sustained by food, grown through water, obtained by devout action and work.

7. Mythologically Ganga (Water) was brought down to Earth by Bhagirath and Lord Shiva received the impact from the heavenly fall in his matted locks and let it flow without turbulance on an onward journey to the nether world to sanctify the ashes of Bhagirath's forefathers: Looked at allegorically if the mighty Himalayas sprung up from an upthrust from the sea of Tethys, the intense erosive action of heavy downpours of rain on top sea bed soils is not difficult to imagine. We have experienced what ravages the Kosi rivere has caused with its heavy silt charge. Ganga in 1970 silted up the Upper Ganga Canal with 40 mcft of silt in a matter of days. The only remedy is a well maintained thick forest cover. Can we not interpret the matted locks of Lord Shiva on Mount Kallas, as well preserved forests in the Himalayan slopes? We practice less than we preach.

8. By referring to any good atlas you will notice the Sugar island at tho mouth of Bhagirathi (now Hooghly) and further downstream the swatch of the Bay of Bengal meaning thereby a bottomless marine canyon or the nether world where the ashes of Bhagirath's forefathers had to be sanctified.

9. We also call Ganga, Jahnavi. This name is derived from Sage Jahnu. As Ganga flowed it flooded the Ashram of rishi Jahnu who got angry and swallowed it up, and let it out in a regulated flow through his ears. So the word Jahnavi. Allegorically there could have been an obstruction or a dam which impounded all the flow, and passed on a moderated outflow of a spill.

10. We thus possess a rich heritage in the management of water & land. Only there was a break in the continuity of such knowledge and its why & wherefore.

Modern Hydraulics

11. Hydraulics as we arc now taught in the Engineering colleges had its history traced by Profs. Hunter Rouse & Ince in a masterly way. Pascal in the 17th century in his "Principes de Philosophic" said "As for the first cause, it seems to me evident that it is nothing other than God, who by His Almighty power created matter with motion and rest in its parts, and who thereafter conserves in the universe by His ordinary operations as much of motion and of rest as He put in it in the first creation". Pascal who experimented "with Syphones, syringes, bellows and various tubes of different lengths, sizes, & shapes with various liquids such as quicksilver, water, wine, oil, air and so forth" lived only a brief 30 years of extreme ascetism, devoted intensely to religion.

12. In the 18th century we had Daniel Bernoulli whose name every student of hydraulics knows. He belonged to Basle in Switzerland. where his father Johann was a famous Professor of Mathematics. So was his uncle Jakco. Daniel's brother Nikolous Was also a mathematician of repute. He won his first prize (out of the ten he won) from the Paris academy des Sciences at the age of 24. His third prize he shared with Euler & Maclaurin. 11 Scotch mathematician whopresented his first paper to the academic of Sciences at the age of 13, and was elected to the academy at the unprecedented age of 17 through his second paper.

13. We feel dwarfed before those giants. Should we be frightened to emulate and carryon the rich legacy we have received from them.

Water for man

14. That no human existance could be sustained on the m aon is now clear from the experiences of the astronauts. We have therefore to live with our problems and solve them on this planet. It is now increasingly realised that fresh water which is essential for human existance is a finite quantity and not unlimited. The increasing population and that disharmony between the distributiou of population and of fresh water is a global problem. Fresh water in the shape of ice bergs in the polar regions are far separated from places of dense human habitation. The Natural resources Committee of the U.N. is already seized of this problem of "outlook for the future; availabilities and demands". They are collecting background information geared to years 1985 & 2000 to be presented on a global, regional and basin wide basis.

Pollution

15. At this juncture a new aspect of water resources development is very much talked about. I refer to the environmental pollution & ecological imbalances caused by the present processes of water resource management. Some believe that this aspect is being over emphasised to act as a brake on the developing nations who are out to catch up with the developed nations. It would also be unwise-to ignore the after effects of atmospheric & fresh water pollution that the developed nations are facing now. The present pollution levels in developing countries are low and polluted areas are widely scattered. So long as certain reasonable ceilings are observed and concentrations avoided, the financial loading on the costs of projects due to environmental & ecological considerations should neither upset the benefit cost picture, nor prove to be a constraint on the pace of development.

16. For mere survival, we have to prudently manage our water resourses, conservation by interbasin transfers, by observing economy in the use thereof and by not polluting the available and limited resource.

Before going over to the problems of water availability and demand in regard to India, some dilation on the environmental & ecological problems related to water resources management would seemcalled for.

Trade efflents

17. These are highly toxic and the toxicity varies with tho Industries and processes. The Central Public Health Engineering Research Institute is fully qualified to conduct research and ad vise the entrepreneurs about the treatment and the quality of effluent that could be let into the streams where no dilution is possible for 9 months in the year. It is a subject by itself.

Demestic & Municipal Effluents

18. More and more cities are adopting water borne sewerage systems. Blessed with it tropical climate and many sun shine days, effluent from shallow aeration ponds used on land for irrigation, alternated with flow irrigation from canals ought to keep down pollution levels, of the regenerated flow in the nalIas within limites.of Public hygene standards.

19. In domestic use, the highly polluted are the closet waters whereas waters from baths, kitchens, & wash basins form the major part are relatively harmless and susceptible of being recycled at low costs. Can we therefore segregate these two? Can the closet water volume be reduced? We are accustarned to use 3 gallon for every flushing. In Sweden, a vaccurn flushing system only uses one litre of water. It is a problem of the urban areas. In India major population is in rural areas, people go out into the open, and far away from the residential area. The problem is nipped in the bud. One should address himself the question. Is universal urbanisaticn good?

In a world of limited fresh water resource, with the threat of an increasing population looking forward to a mere and more comfortable Iife, where should one draw a line for urbanisation?

Irrigation Canals

Though not a pollutant. unplanned, & undrained borrow pits are ideal breading places of malarial mosquitoes. Whether it be in canal construction or in road construction, need we have borrow pits on both sides? Could Wenot plan all borrowing of Earth from one side and see that the borrow areas arc well drained. This can be done and has been done - but a will to do so seems lacking in general.

Dams and lakes

21. This activity of building dams, to conserve the surface water resource has gained increased momentum all over the world particularly after the World War II. After quarter of a century of such activity, the negative side of these new storages, are being brought to notice.

22. The imbalances most talked of are (3) interference with aquatic life and its biological cycles particularly fish. (b) trapping of silt which otherwise was enriching the fields in the flood plains and in the deltaic regions. For example, the catch of fish in the Nile delta is said to have dropped down drastically after impounding started in the Lake Nasser behind the High Aswun dam. The Nile delta, it is feared will be impoverished hereafter by the total arrest of silty flood waters in the lake. These need to be quantified in a benefit cost study, Quantification is either slurred over or brushed aside, in the high pitched sentimental protests.

A new phenomenon which Seems to be (so far as I know) mostly restricted to the African continent, is the infestation of the big lakes by snails & worms responsible for biherziasis. Aquatic weeds render the lakes unusable for recreation or domestic use. Particularly the Volta lake formed by the Akosornbo dam in Ghana has such a high concentration of manganese that the whole concrete structure of the spillway & the chute was coated in deep chocolate brown colour and the waters are unfit for domestic purposes. Secondly at the same place the conditions on the spillway were conducive to the breeding of the "blinding fly" increasing the incidence of blindness.

23. Increased seismic activity has manifested itself, may be fortuitously, but simultaneously with the formation of some half a dozen large lakes. Particularly after the Koyna earthquake of December, 1967, this phenomenon received so great a publicity, that a famous physicist Prof. Rothe of Strassbourg came out with an article "Fill lake, and start an earthquake". It is not possible to deal with this subject in depth, in the present talk. The mechanics of such triggering a majer shock has not been so far satisfactorily explained at Koyna. Based on hardly one or two percent cases of the total number of dams, where such phenomenon is experienced, generalisation ill unwarranted. If we further separate out the dams in known seismic regions from those in regions of low seismicity (if you do not want to use the word non seismic regions) the oc-currences in regions of low seismicity are rare exceptions. Even in areas of known seismicity, such increased, seismic activity has not be experienced at most dam sites. In India itself, the mighty Bhakra and the Umium Bara Pani, in a known seismic belt, did not show any increased seismic activity after the first impounding for nearly 12 years, Nevertheless dam designers & builders have to be alert to the fact that in this vibrant globe, what vary are the periods of quiescence between the shocks, on different regions. Prudence would call for normal designs being adopted in areas of low seismicity, along with seismic instrumentation to study in advance the intensity of pre-project and post-project seismic activity. Provide for a modification of the section of the Dam durimg the initial construction itself but in the later period of construction in case increased seismic activity is noticed on and after the first filling.

24. We need not therefore entertain any apprehensions about ecological imbalances and environmental pollution. An acceleration not retardation of dam building is our need.

25. We may devote some time to economy in the use of water together with the availability & projections of future demands. Water is used for (a) Domestic & municipal purposes, (b) agriculture i.e., irrigation (c) Industrial needs (d) Hydro-power generation, (e) navigation (f) Pisciculture (g) recreation. Flood moderation and therefore flood control is an aspect of a dam building but not a use of water. Hydro power generation, navigation, pisciculture recreation and flood control are non-consumetive uses where economy does not arise. Data regarding the consumptive uses of water in selected countries is tabulated here below:

MAJOR WATER-USE DATA OF SELETED COUNTRIES

Country	Total withdrawals (1965) (incubic metres per person per year)	Distribution of withdrawals among major categories: Municipal and rural water-supply (Percentage)	Agriculture	Industry
Belgium	80	20	2	78
Bulgaria	615	8	72	20
Czechoslovakia	285	13	6	81
Federal Republic of Germany	245	20	10	70
France	540	13	38	49
German Democratic Republic	380	8	12	80
Hungary	390	9	45	46
India *a*	600	3	96	1
Israel *b*	630	16	80	4
Japan	710	10	72	18
Mexico *c*	920	4	91	5
Mongolia	135	12	80	8
Netherlands	125	16	4	80
Poland	250	13	17	70
Romania *c*	160	7	48	45
USSR	1,000	8	53	39
United Kingdom	200	31	3	66
United States of America	2,300	10	42	48

a/ Data for 1968

b/ Data for 1960

c/ Data for 1970

d/ **Estimation on industrial uses based on indirect data.**

India is at one end of the spectrum with 96% of water being used for. Irrigation and a total of 99% for Irrigation and water supply. Mexico is somewhat similar to us. Developed countries like - Czechoslovakia & Netherland & German Democratic Republic are at the other end using 80% for industries 31% of its water utilisation in U.K. is for domestic purposes.

26. Our case is obvious; economy in the use of water for irrigation, is needed Self introspection in each state administration will do some good.

27. The main irrigated food crops are wheat and rice.

28. Wheat is grown mostly in winter and bulk of it in the Indo-Gangetic alluvium under irrigated conditions. Quite a large quantity is also grown on rain in the Madhya Pradesh Malwa plateau and adjacent areas. The Mexican dwarf varieties adapted to Indian conditions, are successfully grown because of one climate, one soil variety and irrigated conditions. With chemical fertilisers, people believe that more water is needed than in the past for the native varleties grown without fertilisers.

29. The case of rice is different. It is, we believe, a water loving plant. I have used the wordt "we believe" advisedly because we do not know what the rice plant feels about this matter! Does is need all this water for its growth? A delta of 60" i.e. 5 acre feet would mean about 6250 tons of water per acre. And what do we get as, the weight of rice crop including the straw? A fraction of the weight of watcr applied.

We also know that the weight of soil in the field does not at all reduce after a crop is grown.

The plant is the result of interaction plant nutrients, solar energy and water on theseed sown.

Economy in the use of water for irrigation would call for intense agricultural practices involving more human effort than what is put in at present by the farmers. Israel is a country where, fresh water is as scarce as gold. They show a film on irrigated agriculture with phenomenal yields for export to Europe. Through a perforated plastic pipe drops of water literally impinge into the root zone of each plant. Quantity of water is regulated.

measured and controlled by the farmers using Walkie & Talkie pbones & electronic devices. This film should be shown to the farmers all over India. to rcalisc the gap that we have to bridge.

30. Secondly unlike wheat, rice is grown all over India:- from Kashmir in the north at high altitudes to Kanya Kumari at the south and at sea level, from Gujarat to Meghalaya, in alluvial deltas as well as in hard rock areas, in high & low rainfall zones, both in the cloudy hot humid monsoon season with lesser number of sun shine hours as well as in the Rabi season with sunshine all the time.

To ask for the development of one high yielding variety of rice which responds to chemical fertilisers in any location, any climate, and any season is not easy.

31. The eating habits form another constraint in the case of rice:- glutineous varieties (good for eating with chop sticks) versus non-glutinuous pulav varieties areappreciated in India. Commendable, work has been done at the International Rice Research Institute Philllppines and at our Agriculture Universities of Orissa, Andhra, Madras etc. Work on biological implications requires time.

32. So long as water is not sqld on volumetric basis in the manner that any other commodity is sold and so long as there is tendency to give water free for food crops, why should any farmer exercise economy & increase his working hours & working days? In Maharashtra Water is sold to sugar cane farms larger than so acres, on a volumetric basis. In Israel they assess the amount of water that is needed for a crop and sell about 80 to 85% thereof at a low price and thereafter every % at exorbitant prices as an incentive to exercise economy by the farmers.

Projections

33. Along with steps to economice in the present irrigational use, it is a pre-requisite that we should conserve and put to use all the useable surface water resource, conjunctively with ground water. By not using ground water we do not lose it. It gets recharged annually to restore the ground water balance, except where the annual draft is far in excess of the annual recharge. It is not so with the surface waters. We lose every monsoon what we do not store to regulate the flow throughout the year.

34. Estimated trends of water demands in some selected countries is presented here below:

Table (2)

ESTIMATED FUTURE TRENDS IN WATER DEMANDS IN SELECTED COUNTRIES

Country	years	Population (in millions)	Total withdrawal (In cubic metres per person per year)	Municipal and rural water-supply	Distribution of withdrawals among major categories of water use Agriculture	Industry (Percentage)
Hungary	1965	10.2	390	9	45	46
	1985	11.0	1150	8	39	53
India	1968	530	600	3	96	1
	2000	919	850	4	75	21
Japan	1965	98	710	10	72	18
	1985	121	970	18	50	32
Mexico	1970	49	920	4	91	5
	2000	132	1100	8	77	15
Netherlands	1965	12.4	125	16	4	80
	2000	17.9	250	39	3	58
United Republic of Tanzania	1970	13	36	63	35	2
	2000	34	200	20	80	No estimation

In India Irrigation drops from 96% in 1968 to 7.5% in the year 2000. Industrial use will shoot up from 1% to 21%. Per capita annual consumption rises in the same period by 45% (600 to 850) with a population increase by 74%.

35. The cultivated area & irrigated areas in India as of now is as below. For this purpose we have assumed North as above Lat. 23° (Tropic of cancer) and central as the belt between Tropic of Cancer and Lat. 20° and south the peninsula below Lat. 20°.

	IN MILLIONS OF ACRES			
		IRRIGATED		
	Cultivated	Surface	Underground water	Total
North	181	41	17	58
Central	74	5	3	8
South	145	27	7	34
	400	73	27	100

Present Per Capita annual consumption of 600 cm i.e. 21,000 cuft represents 1/2 acre foot i.e. = 260 mart for 530 million people of which (pro-rata to areas) 190 maft could be from surface water resource.

36. Our surface water resource has been estimated at 1350 mart, out of which only 450 maft were said to be useable. To use even this quantity, much of it has to be stored. The unusable is the yield of the Himalayan rivers Gagnga, Gandak, Kosi of the Ganga Basin, Brahmaputra, and the west flowing rivers of Konkan coast receiving intense rainfull.

37. At the present estimates, a population of 550 million & a usable run-off of 450 maft yields a ceiling of 0.8 rnaft per capita per year of surface water resource. As the population increases the per capita availablity decreases. Should not the targets in the plans for irrigation be better mentioned by maft. to be conserved and put to use or by the projected rise in per capita use in maft. per year, instead of in money values or expenditures in a plan period? Such physical targets may be more meaningful to the farmers & the common man, better than the expenditures which are inversely proportional to physical targets because of the annual price hike.

38. Apart from efforts to harness us much of the usable surface & ground water resource, we should examine how to meet the future demands of the increasing population. Increasing expectations add pique to the situation, New sources, or ways and means of bringing into use as much of the presently unusable resource, are the obvious solutions. Simultaneously the imbalance in availability and demand within the country has also to be rectified.

39. In a global startcgy the floating of lee bergs to places of need is considered till now infeasible.

40. The quality and availability of geothermal and geopressurc sources in India are still to be known. We may not expect much from these sources and furthermore they are exhaustible.

41. We are therefore left with the idea of attempting to use the presently unusable part of the surface water resource and in so doing rectify the imbalances between demand & availability. With the given global political structure, ajdustments of population according to a vailability of water bas more hurdles than we can solve. A similar approach within India looks no more easy, as Socio-economic problems involved transcend financial evaluation. Secondly the regions blessed with adequate & usable water resources in India are already very heavily populated.

42. The diversion to the east of the West flowing, narrow, steep & numerous water courses has to overcome problems of scattered numerous dams of inadequate capacity, erraticity of pumping capacities. So germinates idea of linking Brahmaputra with Ganga & Ganga with the rest of the country to the south. In so doing, our studies aim at "how best can more water be made available to the scarcity prone areas". The twin objectives of trying to bring into use a part of the presently unusable part of the surface water resources and of rectification as far as possible the inadequacy of water supply to scarcity prone areas are not disputed but the idea of the linking canals for trans-basin transfers of waters has been the recipient of praise and also some crticism. The Secretary General to tho U.N.H.E. Kurt Waldheim made a special mention about the scheme in his inaugural address to the 3rd Session of the U.N. Committee on Natural Resources and praised it. The criticism has neither brought out alternatives nor constructive new-Ideas nor suggestions for improvements for an earlier achievement of the twin objectives, nor modifications which would improve the present idea. There is lot to be investigated in detail. What has been narrated is only in a skeleton or conceptual form & not at all in any shape of finality nor with a closed mind to helpful suggestions to improve and to give our best to our country .

43. We may not perish, but we shall definitely not prosper if we fear from a boldness of conception, and if we r,lt,er in our faith and.in our ability to work together for a high aim. The poor are to be raised to prosperity. It cannot be done by the proud being brought low. We can aspire, for heaven-on earth, but we must have an unflinching faith in the words of Adi Sankara.

"Swadeso Bhuvanatrayam"

The Eighth Nidhu Bhusan Memorial Lecture was delivered during
the Fifty-fourth Annual Convention, Poona, February 14, 1974

Technology, Revolution and Spiritualism

Dr Triguna Sen

Friends and Colleagues,

The invitation to deliver this year's Nidhu Bhusan Memorial Lecture came to me as a and a temptation --- challenge, because the purpose of the lecture is so novel and comprehensive that even the most knowledgeable among us will find himself completely disarmed before coming to the rostrum to tackle such a theme, and temptation, because it gives me a rare opportunity of self-introspection and self-clarification in matters which in my otherwise so-called busy career I had practically laid aside. What I would try to say today is all commonsensical, but I can assure you that this will be commonsense plus confession plus anxiety expressed on behalf of all my countrymen and all mankind.

The world today is passing through what is called technological revolution. The process started towards the end of the 18th century with the beginning of the Industrial Revolution in England, and today with cybernetics and computer, space research and Atomic physics, mankind is experiencing another unprecedented revolution. The world has gone through a number of other revolutions too, such as the French, the American, the Aussian and the Chinese revolutions, that have so radically changed the political maps and social value structures of the world. In our life-time, Shri Aurobindo in India visualized still another kind of revolution which we may call spiritual revolution that promises to transform man into superman.

Revolutions are always supposed to be spectacular and dramatic happenings, and are not usually looked upon □ end products of a long chain of evolution. But the fact is that all the rapid changes in science and technology, were had e possible through a series of break-through, just as the democratic and socialist revolutions were ultimately possible, thanks to a series of change in political thoughts and organizations and a long series of struggle for the Rights of Man. It may sound paradoxical that although technology is supposed to be antagonistic to spiritualism, it is the technological revolution which is actually hastening the process of spiritual growth and evolution, thereby preparing mankind for an ultimate spiritual revolution. It is true, no revolution can be predicted in all exact details, for, a revolution chooses its own time and comes when it comes and in a manner that often belies all forecasts and expectations.

Man's two major aspirations have been Power and Peace. The quest for power has led man to suffering and misery and consequently he has been compelled to forsake the booty of power and go in search of peace and happiness in other places. Spiritualism is the result of this search of man for peace and deeper tranquility. If we agree that science, culture, art, religion and spiritualism - everything is, first and foremost, for man, then the question of human well-being, cannot be ignored or bypassed in any of our philosophical queries or socio-political investigations. Man the known and man the unknown, man who is social and political, and man who is individual and alone, both have to be taken into consideration with equal emphasis in all our serious deliberations. Any lopsided growth or development, any excess in one direction, is bound to affect his future adversely, and may even blight the human species for good.

It is through trial and error, and sometimes through terrible devastation and holocaust, that a society learns its lesson. Those who come first in the field bear the burnt and suffer most. This is true in technology as also in politics. The country that plays the role or the first mid-wife of a social, political or industrial revolution, suffers its shock most. Those who come after become wiser by earlier instances and get an opportunity of avoiding the possible pitfalls and side-effects. Those who are late in the field can plan and reap the harvest more rationally and more economically. In the West today there is already a kind of hangover from-over-technicalisation and a consequent yearning for spiritual anodyne. We in India, stooping too intently to sophisticated mechanization, are on the threshold of a sort of mini-revolution in technology; and being late in arrival we should take the maximum benefit of others experiences, and should plan our affairs in such a way as not to foster an extremely lop-sided growth in any direction. An explosion of material riches, whenever that occurs, demands balancing by a corresponding explosion of spiritual riches, and in India it needs no extraordinary effort to prepare the nation for such balancing, as we have indeed a very long tradition of such a viewpoint in our cultural history. In order to reap the best results of material growth and prosperity, it is essential, said the wise men of the Orient, that such prosperity be buttressed by spiritual affluence also. In USA, for example, we see there is a definite groping today for spiritual solace for which their technocrats forgot to make any provision whatsoever. The Hippie or the Harekrishna movement and other similar movements are but an index of the unrest and angst caused by an appalling spiritual vacuum in the midst of plenty and abundance.

Technology may be taken as the spearhead of science, and the marvelous achievements of modern technology have helped the rapid conversion of man to a faith in science and scientific attitude. Science is daily demonstrating how it can accurately predict without the help of any divine inspiration or esoteric power. The prognostic power of science is generated by its systematic study of the laws of nature. Science can invent no law, it can only demonstrate and utilize the law that already exists and operates in nature. It seeks to confirm that the natural phenomena are regulated by certain uniformities or rhythms. Had there been no rhythm in nature there could be no system or law in nature and, in that case, nature would have been totally incomprehensible to man, and in consequence there could be no possibility of any science at all. Human activities in that case would have been mere operations of chance or just a bundle of accidents. A scientist is merely a kind of seismographer in a limited field carved out of the universal rhythms vibrating throughout the creation. The real epicentrum of the seismos may not be known to ran except in a very dim way. Science deals with the functional existence, but existence itself may be derived from and integrally connected with, the more fundamental essence of matter. Science is not revelatory, its truth is prognostic, and all scientific prediction is really a predication, that is, an assertion according to the known paradigm of a natural phenomenon. The functional existence of a phenomenon which science seeks to study has no basic antagonism to ontological 'essence' of the same phenomenon, which spiritualism seeks to probe. For, the whole truth of creation is simultaneously functional and ontological, and while science specializes in the former, spiritualism does in the latter.

In India, ontology was more than mere philosophic speculation; it was developed as science, and its findings were placed as verifiable by all. The 'science' of ontology has both theoretical and applied sides. The, theoretical side is covered by Metaphysics and the practical by Yoga of which the greatest exponent in modern times, and perhaps one of the finest in the present millennium, is Sri Aurobindo. I had the fortune to serve as Principal to an Institution of which the first Principal was Shri Aurobindo whose centenary we observed all over the country. Shri Aurobindo signifies today the most universal implication of Yoga whose earliest cradle and laboratory was India. It was Shri Aurobindo who asserted that whatever is natural is also supernatural and whatever is human is by implication, also superhuman. The civilizations of the world, despite their local manifestations of suspicion and arrogance, are drifting unmistakable towards a grand congruence which we may call a mega-civilisation, just as the micro-polities are tending through local strife and struggles to one macro-polity or another. Planning for prosperity is all right, but planning for happiness and pence is no less important, and surely far more difficult. A simple limitation or transplantation cannot give satisfactory result even in the sphere of creature comforts, for, even comforts have local colour and flavour, India, therefore, has to choose, pick, modify, adapt and absorb, and cannot affort to ba just a blind imitator. Unless and increase in quantum means also an augmentation in quality, more accumulation or acquisition cannot be called progress or regarded as relevant for human needs. Progress should be determirled by the addition of value. Value is the vertical axis of progress while the mere increase of consumer goods is just linear growth end a description of pseudo-progress. In the human society today there is a widespread demand for quality. The piecemeal revolts here and there, all over the world, are perhaps a prologue to an overall socio-cultural revolution in the making. It will be foolish to try to meet this new revolt by the old concept of discipline. The new revolt calls for a new discipline, quality to match quality. Confronted by unrest or revolt we often pose to be responsible by condemning outright any and every challenge that comes up as breach of discipline. But to condemn a revolt without going deep into the root of revolt is nothing but colossal irresponsibility. The world-wide hankering for justice and sanity is engendering this new revolt against a society ruled by profit, motivated by cash nexus, dominated by ruthless competition and run by mutual aggressiveness. Even in the midst of plenty, people are finding that man who invented tools, is himself now reduced to a mere too1 of his tools. The heartless, competitive society allows no room forth self-identity of man and, as a reaction, a large number of young men and women feel alienated from society altogether. Although affluence seems to be the only reply to object poverty affluence itself has to be balanced by mental and spiritual well-being, as otherwise it will only pave the way to alienation and self-annihilation.

According to the theory of Evolution, all life process is progressive differentiation of the relatively simple into the relatively complex, the increasing differentiation being also more and more individuation. But this is an incomplete and one-sided account of the process; for in the total span of evolution, differentiation is balanced by new integration, difference by unity, and development by regression. Even this description, taken as a whole, is one of mechanistic causation. Bergson, initiating his theory of Creative Evolution, challenged this stand of mechanistic biology by suggesting elan vital or life-force as the real impulse or electromotive forced, behind all evolution, thus turning the tame concept of pre-determined selection into a great creative adventure of life-force. This vital principle introduced by Bergson in the idea of evolution made the theory of evolution a little more meaningful, but not direction-oriented. Life-force is a kind of urge without which no creation is possible. Bergson did not admit any goal for evolution; he described it as an open, indeterminate phenomenon with divergent multi-directional possibility inherent in it. Bergson compared evolution, which is always unpredictable, with a work of art. It is prompted by an undefined urge in the artist which can only be fore glimpsed but can never be foretold.

Like art or poetry, evolution is a kind of creative outburst or explosion that surprises everybody by its outcome. The Emergent Evolutionists went one step forward end admitted two simultaneous principles in nature - the resultant principle and the emergent principle. The resultant principle reveals what is latent and already underlies, while the emergent principle admits the advent of something absolutely new, not predictable from the given data. According to this view, there have been two critical stages in evolution at the first, there is emergence of life, and at the second, there is emergence of mind; and neither of the two was predictable before the event of its actual emergence. Shri Aurobindo goes one step further, he claims that the third critical stage of evolution which is maturing, is the emergence of spirit and this is going to raise man on to a higher plane.

Life is a unique kind of energy which is awake. All other energies are locked in eternal unknowingness. Being more

and more awake, it is aware of itself and becomes free as nothing else in the universe is. Its freedom is constituted by its awareness of choice or alternatives of action. Life is unique because it is creative, capable of developments beyond the power of prediction. It is unique in that it learns to become a master over other energies by utilising them for its own expression and manifestation. Life is forever aspiring, trying, needing, building, annihilating, rebuilding and seeking again. It reveals its deeper nature in its constant weaving or relationships with its environment, with other lives, even with the dreamy cobwebs of its own imaginings.

Man gifted with mind has acquired power. Power always wants to be free, that is, more and more powerful. But it often misunderstands the conditions of freedom. Freedom of action which is almost synonymous with power is called forth by the creative urge of youth, but when this is not controlled by a sense of responsibility, it becomes destructive and proves inimical to the freedom or others. Historically speaking, the power of man over man has existed from the dawn of society. It is rooted in the regulation within a family, in the parents ruling over children, the seniors over the juniors and the patriarch over the clan. But we should note that this power has never been primarily a question of' physical strength. Authority was inherent in the very nature of society. Seniority was reinforced by indoctrination and training, by the accumulated know-how of longer life and greater experience.

Power that rules the world of men, exists always within a system or relationships. It is not something which men possess exclusively like the quality of perseverance or strength of muscles; nor is it like legacy or gift which can be transferred in toto from one person to another irrespective of other things. What can at best be transferred is only a potentiality; an opportunity, a congenial possibility, no more'. The Hobbesian concept of power did not take into account the social matrix of' power, and, therefore, Hobbes mistakenly regarded force as the power that keeps in subjection. But, Power, on the human level, means capacity for effective action which depends on the utilisation of resources through the know-how, know-what, know-when and know-where. The knowing is primary, for knowing itself can subsequently be in possession of the resources it needs, and it is knowledge that triggers all worthwhile achievements.

The two basic abstractions in the heritage of modern thought - the Newtonian doctrine of the Simple Location of material bodies and, the Cartesian principle of the Separation of Mind from nature are also arbitrary and by no means absolute. First, the doctrine of Simple Location. It regards the independent individuality of each unit of matter whose properties could be tabulated correctly without reference to what was happening elsewhere in the world. Its reality is supposed to be fully manifest at particular moment without any need or reference to its past or future. Modern physics has abandoned this Newtonian doctrine of Simple Location and the physical entities like the sun, the stars, the planets, the molecules, the electrons are each regarded as modification of conditions within the Space-Mme continuum. There is a focal region where we say a thing is, but its influence really flows away from it and pervades the remotest recesses of space and time. Secondly, the Cartesian bifurcation of nature into two systems-one, governing the nature of electrons and light quanta, which are the domain of physics, and the other, governing the nature of the poets and painters-nature endowed with the glorious rainbow in the sky and the vernal wood, causing remantic ripples in the lover' s mind, which the scientists have so far excluded from their enquiry-cannot also be accepted as absolute bifurcation. in the name or science can we exclude a significant part or fact of nature—the glorious sunrise and sunset, the sunflower in the bush end the down chorus that generate emotion and poetry and music-as if it belonged to an ‘unscientific' nature? Are not these surprises and surprising segments of nature as much natural as are the molecules, electrons and protons? Perception gives us only n structural not qualitative knowledge of the external world. Science can quantify, but not qualify; it leaves untouched the mystery of the emergence of quality in the creation. Besides, the experiments of the post-Einsteinian world, the handling of the astronomical data and the far-off phenomena in the super-steller universe have raised new doubts about the scientific cocksureness of the past. The time-lag however small, between the causal nature and, the apprehended nature brings in the possibility of a gap between' what the philosophers traditionally demarcate ns Reality and Appearance. It is, after the perceptual reality which the scientists accept as reality. But if we ponder well, we may see that there is no objective existence as such, and what we normally accept as objective is invariably an subjective-objective continuum in which matter and mind are not disparate items but coherent pulses in the total flux.

Humanity seems now to hoist in its own petard. The nuclear weapons have put mankind into such a dilemma that it does not know whether it has already reached a point of no return. Escalation is a definite danger, but in the logic of nuclear logistics, deterrence-threat plays a key role. The possibility of escalation spirals upward, through the intermediate levels of violence towards the highest violence-total nuclear war. What appears at higher level to be mutually oriented deterrence is really a balance of terror only- the reciprocal capability of launching massive reprisal to annihilate or nearly annihilate each other. It implies ability which is sufficient to annihilate the enemy's society but inadequate to destroy the latter's retaliatory weapons. The 'balance of power' at various levels of violence, issues from the balance of terror which throws a pall over the entire society and brings - in its wake anxiety and alienation. This balance of terror does not imply any capability to halt the enemy's advance, but to punish the enemy by paying it back in its own coin. Against this background, the question arises: Was a new world really born on the 6th of August, 1945, when Hiroshima was bombed? For many centuries mankind has dreamed of an age of everlasting peace when nations 'will beat their swords into ploughshares' and violence among men will have vanished from the earth. With the same optimism, mankind has adopted a technological view of history that it embodies a 'hidden purpose' which is fulfilled through ages. But today we find, ironically enough, that Pax Atomica or atomic peace has been reached by means of nuclear deterrence. Surely this is not the kind of peace of which mankind has dreamed for generations. The peace we are confronted with is 'peace in the shadow of terror' ; this is a negative coercive peace imposed by improved technology, peace with latent violence and aggressiveness. It is a hostile peace with constant preparedness for war, an armed peace, over which violence hovers like an evil cloud. It prevents war without solving the conflict and without trying to eradicate the source or tension. In our age of deterrence, 'co-existence' does not mutual tolerance based on 'live and let live' or anything of the kind. Co-existence is double- edged term in the international political vocabulary, it means continuation of conflict by avoiding mutual destruction. This is neither peace nor war, a paradoxical situation which allows war in the political arena and peace in the military.

Peace as a military or political proposition has thus been blunted. Peace has ceased to be a matter of agitation, protest end sloganning, it has become a difficult subject of research in depth. 'If you wish for peace, understand war' is an old Roman dictum. If prevention of war is peace, the circumstances that cause was must be investigated, and a general theory of peace and war has to be evolved by taking into account both positive peace and negative peace. The conventional weapons were used to be produced, on the assumption, that they would have to be used; but today the nuclear weapons are developed on the contrary assumption and hope, that they will not have to be used at all. At the same time it is feared in some quarters that if in Europe nuclear deterrence is not actually implemented and aggression is met only by conventional weapons, Europe will be defeated and lost, but if they are used, Europe will be destroyed. The politicians of deterrence hold that nuclear weapons. have become a kind of force for peace. But this politics does not, and cannot ensure that peace will endure. Mere lack of war is surely not peace, and whatever results nuclear peace may have achieved, it has not achieved peace of mind. This peace in a global community of fear is, in the very nature of it, very dehumanizing. People have started saying that with the advent of the nuclear era mankind has entered into a blind alley and that his survival depends upon beating a retreat and changing his ways and wants together. A new world order based completely on different postulates is on the agenda, but there seems to be no power or agency capable capable of bringing it into reality. Man has travelled a long way and has tt his credit a lot of important achievements. Nevertheless, the world is farthest away from his cherished goal of peace, joy and serenity. Ours is still the earth suspended over an abyss as it is described in the Book of Job in the Bible. Uptill now peace has been tackled by war, as if war is the only means of peace. Now we have to think of tackling war by peace, believing that peace alone, not war, can win against war. And this means a total change of outlook, a total re-structuring of the societal ethic and attitude. India can play vital role in this matter by recalling her ancient tradition and championing the cause of world peace by setting it in a new spiritual key.

The scientists of the first two Worlds are still using terms of conflict and warfare while they are supposedly working for peace. Take the example of the ecologists. The ecologists invariably use the term environmental control. They do not realize that the very idea of control or controlling the environment may defeat the very purpose for which the aid of ecology is being sought. They are trying to control the environment when they should rather 'free' the environment. How can we use the environment for the freedom of man without first freeing the environment? The notion of antagonism between man and nature is the legacy of western thought, and unfortunately our Indian ecologists are just repeating their western gurus without even once trying to reformulate their borrowed knowledge and avoid their extensive blunders. Technological revolution limited to technology alone, can be as disastrous as atomic revolution limited to atomic experiments; both can easily lead to sort -of escalation not originally meant. The monotony of over-organized , over-urbanized life, standardized stereotypes of education, breathless, unimaginative and uncomfortable transport and communication media—all these are going on in the name of technology end progress. The abominable uniformity of our neighbourhood cannot but cripple the mind of the growing child and blunt his imagination. It is often repeated that human progress means, and depends upon, man' s ability co conquer nature. In reality, however, there has always existed in man' s long history the biological and emotional need of collaboration with, and not conquest of, nature. what we see today is very dismal in most parts of the world. Everywhere men seem to be willing to accept ugliness and squalor on the ground of economic wealth and prosperity. A landscape can retain its beauty—as in the old Indian concept of Tapoban like Naimisharanya-only so long as it is not found suitable for economical or industrial exploitation. In the name of taming nature, technological civilization has only turned wilderness into sorts of dump heaps through a process the raping the nature, and destruction of the environmental harmony and beauty. It should be the task of our new technology to reconvert the drab wilderness that has been generated by technology itself, into new kind of civilized nature, in conformity with the well-being and spiritual growth of man. To forget the geographical imperatives and the topographical and climatic peculiarities attached to a spot is to doom urban planning ab initlc. The physical and biological implications have so far been disregarded in favour of economic and political urgencies. Planning without the proper use and utilization of the environment and without the human inhabitant and his free growth in focus, is bound to be a failure. Air pollution, noise, misuse or overuse or drugs-everything results from the environment being manipulated exclusively on the basis of technological imperatives without making provision for man's psychological, and I should add, spiritual well-being and growth. Ecology, which the German scientist Ernst Haeckel introduced as a scientific term in the last century, has to be taken now in a much broader concept. It has now to include the mental as well as spiritual environment of man. But unfortunately questions of man’s spiritual ecology well-being are still ignored. They talk of ecological equilibrium and harmony in the external world, but what is the use of equilibrium and harmony in the external world if the competitive motive in the structure and organization of society continues to create disharmony and disequilibrium in the inner environment of mind, necessitating more psychiatric clinics and more tranquillizer pills? Man’s brief honeymoons to the moon or even the possibility of an interplanetary shuttle service in near future should not make us blind to the grim fact that our gardens on earth are overgrown with weeds, and the chamber of our mind is cobwebbed with angst and worry. An astronaut's journey in space is much safer than pedestrian’s evening walk in the city, and it proves that we are now able to do the impossible but cannot do the possible and necessary.

We cherish knowledge, but no knowledge can be all-knowing. Between the known and and unknown there will always be a dividing line. There are frontiers even between the inorganic and the organic, between life and mind, and between life and spirit. Our progress in science does not mean demolition of the frontier completely, but only pushing the frontier a little further. The frontier, however, still remains. Science gives no explanation of the world it describes and analyses. Science seems to deal with the book of creation whose first and last pages are torn. We do not know, therefore, the beginning and the end of the process, we only deal with the middle, in the words of the Gita:

Abyaktadini bhutani vyaktamadhyani bharata
Abyaktanidhananyeba tatra ka parivedana

- (O Bharata, all living things are implicit or unknown at the beginning, and so also at the end, they are explicit or known only in the middle. What use lamenting over this state of things?)-The world of science is not self-sufficient; it rests on something which lies beyond it und cannot be known in the physical or material way. A seeker of truth, if he is a scientist, will follow his scientist’s conscience and will reach the frontier which he cannot pass unless he consents to follow the path of another kind of order and experience. This was admitted by Einstein when he said: “The supreme task of the physicist is to arrive at those universal elementary laws from which the cosmos can be built up by pure deduction. There is no logical path to these laws, only intuition, resting on sympathetic understanding of experience, can reach them". The reality is not merely the material or physical reality. The most wonderful thing - and the most real of all – is the human mind which has unravelled thc mysteries of nature. Man has to take the whole view of reality-the subject and object, Puruse and Prakiti, spirit and matter, freedom and necessity, existence and essence. In the name of science, technology, progress, revolution, pragmatism or any other ism we cannot squeeze freedom into necessity, and truth into untruth. It is man's birthright to aspire after the infinite and cry :

A-sato ma sad gamaya
Tamaso ma jyotir gameya
Mrtyor ma amrtam gamaya.

— (Lead me from nonexistence to existence, from darkness to light, from death to life eternal).

Even those who declare themselves to be atheists, agnostics or skeptics and are opposed to spiritualism as such, cannot avoid a tinge of spiritualism in their very intimate thinking and living. Art, beauty, culture, social service and love become to them substitutes of spiritualism. Whatever uplifts, ennobles, frees, is at bottom spiritual, and is needed the enrichment and fulfillment life. One of the greatest intellectuals of this century, Bertrand Russell, wrote the following, in the Prologue to his Autobiography.

"Three passions, simple but overwhelmingly strong, hove governed my life: the longing for love, the search for knowledge, and unbearable pity for the suffering of mankind. These passions, like great winds, have thrown me hither and thither, in a wayward course, over a deep ocean of anguish, reaching to the verge of despair."

"I have sought love, first, because it brings ecstasy – ecstasy so great that I would often have sacrificed all the rest of life for a few hours of this joy. I have sought it, next, because it relieves loneliness—that terrible loneliness,. in which one shivering consciousness looks over the rim of the world into the cold unfathomable lifeless abyss. I have sought it, finally, because in the union of love I have seen, in a mystic miniature, the prefiguring vision of the heaven that saints and poets have imagined. This is what I sought, and thought it might seem good for human life, this is what—at last—I have found."

"With equal passion I have sought knowledge. I have wished to understand the hearts of men. 1 have wished to know why the stars shine. And I have tried to apprehend the Pythagorean power by which number holds sway above the flux. A little of this, but not much, I have achieved."

"Love and knowledge, so far as they were possible ,led upward toward the heavens. But always pity brought me back to earth. Echoes or cries of pain reverberate in my heart. Children in famine, victims tortured by oppressors, helpless old people a hated burden to their sons, and the whole world of loneliness, poverty, and pain make a mockery of what human Life should be. I long to alleviate the evil, but I cannot, and I too suffer".

"This has been my life. I have found it worth living, and would gladly live it again if the chance were offered me".

The ecstasy, the shivering consciousness of terrible loneliness, the Pythagorean power of knowledge and the infinite pity for the suffering humanity — all these have been mentioned by Lord Russell with great fervour. They are a vivid proof and expression of the essential spiritualism in man which Lord Russell himself would vehemently deny In his other writings.

Man has developed new weapons for global destruction, but ever since the dawn of civilisation his dream has been to surmount death and decay end to attain light and unlimited freedom. His pursuit of medieval alchemy or modern science has aimed at the gaining of immorality. But this dream of the human race has most of the time been contradicted by its actual experience and suffering. Now at last is time when man should look inward, not as an escapist, but with a view to bringing out the inner light which alone can illuminate his path. That we look upon matter as merely 'material' may be due to our limited vision. We say matter evolves life and mind. But we could also say, like a Vedantist, that life and mind are already involved in matter. The domain of the material study of matter is Physics, the mental study of mind is Psychology and vital study of life is Life Science or Biology. They are al1 limited studies within a given, rigid frame. But why should we be so dogmatic as to suggest that there can be no other study of matter than material and no other investigation of mind than mental or psychological? The more modern developments of para-psychology phenomenology are only hints of the many other possible realities yet unfathomed or unsuspected by men. Spiritualism is an approach to matter, mind and life from an altogether different plane, and if it serves our need and gives us peace of mind and thrill of joy, there can be no objection to spiritualism, simply because it is different. According to Sri Aurobindo, just as the animal is a living laboratory, in which nature has worked out man, so man himself in his turn can be a thinking and living laboratory of nature of work out superman. Nature has not ceased to work just after reaching a particular stage of evolution, it is working on, and its goal is to go beyond to man to superman, beyond mind to overmind and so on. According to this view, matter has become, through evolution, living matter or animal, animal has become thinking and reasoning animal or man, and next, man is to evolve himself Into conscient spiritual man or superman when the indwelling spirit in him becomes so manifest. The veil of inconscience and insensibility, will then be torn as under and only purest intuition will reign. The spiritual and suprementel possibility of man cannot be dismissed as mere speculation, since spiritualism as a science was established in India long before Patanjali. It is a science, a para-science in sofar as it does not ask anybody to believe or accept any of its conclusions a priori but to test, in all science, its validity or otherwise by individual experiment and mental experience a posteriori. Yoga is nobody's monopoly or patent. Whoever consents to follow its steps experimentally will realize its validity and practical efficacy. It does not even require to be a believer in God in order to follow Yoga, and Patanjali's system of Yoga itself does not believe in God: 'Isvarasiddheh.

Today both atheist Russia and Christian America are showing eagerness to study and practice Indian Yoga, whereas in India, far from accepting it as a subject for research in depth, it has been quietly relegated to pretenders, charlatans and mountenanks. We forget that Yoga has no more mystery in it than mountaineering has for the planes people. If you want to climb the mountain, you to practise mountain-climbing, and the practice may be very strenuous and difficult but there is nothing occult or mystical about it. So also in Yoga. It is stated in the Gita that Yoga is a kind of skill in work or spiritual know-how: 'Yogeh karmasu kausalam'. We often claim that man is a rational being, but we know very we1l that man is also a bundle of irrationality. But what we do not care to know is that man can go beyond rationality to supra-rationality. Man's journey from irrationality to rationality and from rationality to Supra-rationality can be accomplished successfully by our instrument of perception, which is mind. The light of reason which science has utilised fruitfully is indeed very feeble flickering light. It never reaches the depths which generate the greater creative force. The creative power comes from the darkness below and the illumination above, in the language of Yoga and Tantra from the bodily centres of Mualadhara and Sahasrara or from a combination of Sakti and Siva or Vija (seed) and Vindu (point) or Prakrti and Purusa, being the nomenclature according to d schools or belief. The transition from mind to supermind is a so transition from nature to super-nature, aided by, what Shri Aurobindo calls, the descent of superconscience or the supramental consciousness-force, so that human intelligence may climb by degrees to the higher mind or illumined, intuitive mind and overmind .

In ancient India, the wisest thinkers realized the profound truth of harmony in nature and they made astounding progress in all spheres, material well as spiritual without suffering from any crisis or alienation. The supposed antagonism between science and spiritualism is a legacy of the western thought, and culture; and our tendency to imitate the west without modification has put us into so much unhappiness and confusion.

The spiritualisin of the ancient Indians did not prevent them from their magnificent and most revolutionary discoveries in Mathematics, Metallurgy, Medicine, Surgery, Botany, Agriculture and Zoology, rather it sustained them in their high pursuits. The conception of the 'Sunya' (zero) and the system of numeration were invented in India centuries before Christ, and while the Greeks developed Geometry almost to the exclusion of other branches of Mathematics, the Indian developed the Mathematics of Numbers with a rare sense of abstraction and boldness of conceptions. It is to be noted that by the 5th century A D Aryabhata wrote practically the whole of Arithmetic that is taught in High Schools now including extraction of square and cube roots, decimals and fractions, the rules of proportion including inverse proportion, arithmetical and geometrical progression, etc, whereas we find no trace of the geometrical propagation use of modern system of arithmetic outside India before the 10th century, not even in Europe, Middle East or China. In Algebra also it was the Indian mathematics who first used the letters of the alphabet to denote unknowns. The Indian mathematicians also realized that all arithmetical operation could be done with alphabetical symbols and arithmetical signs. Brahmaguptau clearly states in Sphuta Siddhanta: 'The product of a positive and a negative is negative; of two negatives is positive; positive multiplied by positive is positive. Positive divided by positive or negative divided by negative becomes positive, but positive divided is negative, and negative divided by positive remains negative'. Having evolved the necessary by the 5th century, the Indians found the general solution of the quadratic equation and solved completely the general indeterminate equation of the second degree. The results arrived at by the Indian mathematicians were unknown then in Europe, were rediscovered only in the 17th; 13th and 19th centuries. The Greeks also studied indeterminate equations but they failed to make much headway because they approached the point of view of Geometry and had evolved the proper symbols. In ancient India, although the general belief was geo-centric, Aryabhata differed from all other astronomers in his belief in helio-centricism. He also maintained that the problem from the Earth actually rotates about its axis. The spherical shapes of the earth, the moon; the sun and the planets was also well-known the Indian astronomers. India also substantial in Metallurgy. She was famous for her skill in the tempering of stee1 and the manufacturing of the so-called 'Damacus blades was from her by Persia end then from Persia by countries. The rust-proof wrought iron pillar at, Kutub Minar in Delhi over fifteen hundred years old is an unmistakable proof the high metallurgical skill of the Indians. They knew the different processes or extraction, purification, melting and casting of metals. The Indians were highly rated by Imperial Rome as industrial experts specialising in dyeing, bleaching, tanning, calico-printing, soap-making, glass-making, steel-manufacture, gunpowder and fireworks, and even manufacturing of cement (vajra-lepa). In Medicine, the two great Indian names are Caraka (medicine) and Susruta (surgery). Surgery, as a well-developed skill was recognized by about the second century, while materia medica grew from age to age with the introduction of new drugs, vegetables and minerals.

Whatever be the ultimate outcome, all revolutions profess to bring freedom to man; freedom which is willed by man freely and also achieved freely, and dependently. Political and other freedoms provide only partial glimpse of the potentiality of man for freedom. Freedom in the fullest sense of the term, can be gained only by crossing the frontier of the domain or materialism and stepping into the region of spiritual illumination. Since there is basic opposition between the two, and since the one rather leads to the other, let us refuse to be short-sighted as we are in our bigotry and arrogance in the notice of science and technology, and strive to different and difficult harmony which alone is the sine guo non of the highest technology, revolution and spiritualism.

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Saintliness in Science and Science in Saintliness

Prof H C Guha, *Fellow*

INTRODUCTION

The subject on which I intend to speak today is 'Saintliness in Science and Science in Saintliness'. It is obvious that the subject is both important and intriguing and the choice of it cannot be over-appreciated.

The subject is important, for it not only draws our attention to the pitiful and tragic conditions of our 'Progressive' time, but also hints at the way, the best possible way of curing it of such conditions. It is also intriguing in that it is an invitation, a challenging invitation to analyse and understand two basic concepts, viz, 'science' and 'saintliness' and as it is 'man', who builds science and as it is man again who becomes a saint, to analyse in its depths also the concept of man.

Accordingly, my exploration of the subject will be (a) a descriptive account of the crisis in our present culture and oivilization; (b) an analysis of the concepts of science and saintliness; (c) an investigation into the nature of man to find out if one may be a scientist at the cost of being saintly and vice versa or if one can be not only a successful scientist but a true scientist if and only if he is saintly as well and also if one can be saintly not only in appearance' but in reality if and only if he is scientific as well; and (d) finally, an attempt at - understanding man in his depths, man in his empirical and transcendental nature.

CRISIS OF THE PRESENT AGE: A DESCRIPTION

The present age, it has already been said, is both pitiful and tragic and it is ironical to describe it as progressive. One need not be too careful to find out that it is an age of alarming paradoxes or, if you like it, of horrible contradictions. There is plenty of scientific and technological knowledge. Indeed it is increasing at every moment and increasing at such a rate that it is becoming difficult, if not impossible, to keep pace with it. But, unfortunately, side by side with it our sense of values is withering even at a faster rate. Our sense of insecurity and helplessness is widening and filling us with despair. The most advanced scientific and technological civilization the world has ever known appears to any man of sense and judgment, using the words of Schweitzer, 'a strange medley of civilization and barbarism'. Social and political upheavals in every part of the globe are daily occurrences. They may rightly be judged to be the symptoms or manifestations of a deep-rooted moral and spiritual disease. Every sensible and thoughtful man seems to be a stranger to this atmosphere. The growth of science and technology has not brought mankind to the promised land. It seems that humanity has met with a shipwreck. One school of contemporary philosophy, viz, existentialism, is occupying itself with the vivid description of dread, nothingness, ennui (boredom) and the like, which to a student of philosophy of earlier days would have appeared as signs of a diseased mind. But the existentialist thinkers are in a sense the spokesmen of this age; they are articulating, though in a dramatic way, the ever-increasing loss of freedom, the total collapse of the sense of values, the obvious outbursts of the Dinosyian elements of man's nature, the eclipse of the Appollonian elements, the growing sense of insecurity. the dread of anonymity or the sense of estrangement or of being thrown in an unkind if not hostile Universe and paradoxically the Universe of 'civilized' men. The same sense of estrangement is expressing itself in the works of the poets, the novelists and the dramatists. Kaffka in his novel, The Trial, tells the story of a man who goes through a trial without being able to find out what precisely is the charge against him. The same author in his book, The Castle, narrates the sad plight of a man subjected to the arbitrary decrees of a mysterious sovereign and fails to get access to 'The Castle'. The poet Rilke in his poem, The Great Night, describes how the big city is inaccessible, how the landscape darkens and makes the human self practically non-existent, how everything becomes unintelligible, how the street becomes oppressively near, how even the nearest things are without shape and the human soul is as it were hemmed in by angry towers and inscrutable mountains and everyone is alone. Rose, the principal character of one of Marcel's ,plays, utters, There is only one suffering: to be alone'. This loneliness is not the U panisadic asangatva of purusha of the saint who has conquered all his passions and inclination and is in communication- contemplative communication in silence with his deeper self-but of a typical modern person who, while surrounded by clever people finds that his longings for an honest companion are unsatisfied. Similarly the initial thesis of the novels of Camus, particularly of The Plague and The Stranger is the absurdity of existence.

From what has been said it would be evident that the human situation is precarious. It may be mentioned in passing that the economic, social, and political structure prevailing in the non-socialistic countries does not sufficiently account for it. It is rooted in our perverse concept of science and well-being. The crisis is moral and spiritual. It is embedded in our false evaluation of the nature of man and misunderstanding of science. Lest this appears to be vague and obscure it should be said that social, economical, and political structures may be to a certain extent responsible for such a condition. But they are not enough to account for the situation-for / even where this kind of structure does not exist, the situation is not as happy as the admirers of the said structure, say, though it is not as ugly as the hostile critics declare. True, it is a question of fact and we do not know what the facts are. We are prepared to accept that changes, qualitative changes in the modes of production demand corresponding changes in the modes of distribution and this requires are-structuring ofthe socioeconomic-political pattern. But we would also add that rapid developments in science and technology are introducing qualitative changes in modes of production so that the socio-economic-political structures of yesterday are becoming out-moded today. Moreover, we do not intend to base our description on an insecure foundation like ill-arranged facts. We intend to obtain an analytically satisfying consideration. And, in fine, it is; that we have misunderstood the true spirit of science. We have entertained the idea that science is ethically neutral, valuefree, in that it aims at knowledge and knowledge for the sake of knowledge. But while entertaining this idea we, whether intentionally or otherwise, did not take into consideration the obvious proposition that science not only investigates its subject but also presents us with a view oflife and so a sense of values. It is strange that even today we do not give sufficient thought to it even though with the development of science and technology the old system of values has crumbled or is crumbling. In other words, if science has brought about a change in our sense of values, it cannot be value-free and the recommendation that the scientist should seek knowledge for the sake of knowledge is hollow. We also did not take into consideration that to everyone except the pure and perhaps anaemic savant, knowledge is power and power is indivisible and so science gives us power not only to control nature but also society and in fact science itself. This power may be exercised not by the truth-seeking scientist but by the power-loving adventurer- the kind of power that makes one corrupt and unscrupulous, the kind of power the power-loving politicians seek. The historians of the middle ages tell us what misery men had to experience because of the unholy union of the unscrupulous kings or politicians and equally unscrupulous or helpless men of the church. And we may say that when the history of this age will be written, if human beings survive the present crisis and survive to write candid history, it will be observed that incalculable sufferings were the lot of men of our age on account of the unholy union between unscrupulous politicians and unscrupulous or helpless scientists and technologists. And if this be the case, then the crisis of this age is a moral and spiritual one.

The sense of estrangement on which many poets and philosophers of today dwell was foreseen in the nineteenth century by thoughtful persons who were not 'idolators of the actual' and they rightly, if sometimes clumsily, hit the nail on the head. Nietzsche spoke for the trans-valuation of values. One may not accept his concept of values, but one cannot deny that he felt keenly that with the rise and triumphant advance of science, the traditional scheme of values collapsed or was collapsing miserably. That is why he often spoke of man as if he was a forelorn wanderer. In one of his books he considers the case of a man, who is not one of the featureless crowd or of the class of people with presumptuous pride, but though behaving like brutes, is worse than brutes in that he is not gifted, as the brutes are with instincts or natural sense to keep them within their natural orbit, but looks at his world with open eyes and is not possessed by the possesing instinct. Such a man is a wanderer. He will have hIS bad nights when he comes home tired and finds the city-gate locked, the gate of the city in which he had hoped to find rest .... then the terrible night descends upon him like a desert in a desert and his heart feels tired of wandering. And when at last the morning sun rises glowing like a god of wrath and when the city-gate is opened then he may discover in the face of the citydwellers an even greater desert, more filth, fraud and insincerity than outside the Igate-e-and the day will be worse than the night'.

Nietzsche is, in the opinion of many people, notorious for his wild exaggerations and there are some reasons for holding that the frustrations and the sufferings that were his ill-fortune contributed to a great extent to the formation of his ideas about the nature and destiny of man. Accordingly the above pronouncement of Nietzsche may be viewed with suspicion, though it will be unfair to discard it as false. But none would attribute the same attitude to Goethe, and the fact is that he was also not happy with the policies we adopted to make ourselves 'civilized'. And he observed: 'Men will become more shrewd and clever, but they will not be better or happier. I see a time approaching when God will no longer be pleased with man, when he will have to smash His creation to pieces in order to rejuvenate it'.

Indeed when one considers carefully the rise and growth of science and technology and also the emergence and development of the scientific and technological civilization, one cannot fail to note that the sense of values which for centuries sustained man's faith in himself and lent to the consolidation and healthy development of the social, moral and political institutions and practices weakened and started to wither away. So what Nietzsche was pleading for passionately was the cultivation of a new sense of values, which he expressed in his characteristic style as the 'trans-valuation of all values'. Similarly, Goethe, the incurable optimist, not only feared that God will one day smash His own creation but also rejuvenate it. Indeed, He will smash and rejuvenate and, I may be excused if I am imitating his manner of speaking, implant in it with a sense of values. I may make bold to add that Marx or a Marxist should not object to it. What a Marxist wants is not a mere restructuring of the socio-economic order or a change in the political set-up. For any de-structuring that precedes re-structuring is not revolution as any change is not a change for the better. Hence, he is after a better socio-political order and 'better' is a value-word. That socio-political order is better which promotes human welfare in a better way, which creates conditions for the expression and enrichment of men in a more meaningful way. This we may say is an innocuous' description of a better order; and a Marxist would not challenge it. What he would demand is an anaiysis of the concept of human welfare, or to vary the mode of speaking, a map of the world of values.

Now the world of values is a heno-dimensional world. It has many dimensions, but pursuit of every dimension not only demands devoted and zealous attention but impresses upon him who pursues it that if it is not the only dimension the other dimensions are subordinate to it. In other words, the world of values is a pluralistic world, a world of many sets and none of these sets is unrelated with the other sets though each set claims to be the super-set, of which the other sets are sub-sets. In plain language, there are economic, social, political, moral, religious and various other kinds of values. They are all connected. But the connection is to a great extent as you connect them. In other words, we do not take them as co-ordinates. We try to find out which is more comprehensive, which is less comprehensive, which is higher which is lower, which is extrinsic a value for and which is intrinsic a value in itself. Accordingly, we arrange them in a hierarchical order, we grade them. And here we differ. What is identified by one school of thinkers. as a value of the highest grade is not so identified by a thinker of another school. And this is not arbitrary. It depends upon the different way of conceivjng man. But before we consider it even briefly, it may be mentioned that even at the common sense level, it is - quite obvious that promoting human well-being is essentially promoting moral values; and in support of it I may quote the following from Winston Churchill who beyond all doubt was a man of abundant practical wisdom.

'Projects undreamt of by past generations will absorb -our immediate descendants; forces terrific and devastating will be in their hands. Comforts, activities, amenities, pleasures will crowd upon them but their hearts will ache, their lives will be barren if they have not the vision above material things. And with the hopes and powers will come dangers out of all proportions to the growth of man's intellect, to the strength of his character or the efficacy of his institutions. Once more the choice is offered between Blessing and Cursing. Never was the answer, that will be given, harder to foretell. .. without an equal growth of Mercy, Pity, Peace, and Love. Science herself may destory all that makes human life majestic and tolerable. There never was a time when the inherent virtues of human beings required more strong and confident expression in daily life-there never was a time when the hope of immortality and disdain of earthly power and achievements were more necessary for the safety of the children of men.' (from Thoughts and Adventures).

Winston Churchill desires that the inherent virtues of human nature should assert themselves strongly and confidently. But a large amount of contemporary thinking is directed against the recognition of anything inherent or essential to human nature. Indeed the very expression 'human nature' is viewed with suspicion .. The existentialistists, by and large, are of the opinion that the idea of fixed human nature or human essence is a fiction. So also the behaviourists hold that a man is how he is conditioned. Recent developments in the science of psychology and in genetic engineering indicate that it is possible to create or manufacture a new kind of human beings and the possibility is not a remote one. This is a fresh case of alarm-the kind of alarm that was behind the satirical works of Huxley and Orwell. Men of sense cannot help being alarmed. The alarm which has been created by the nuclear armaments has been intensified by genetic engineering. For who is going to lay down the rule on the kind of men to be manufactured? If they be the unscrupulous politicians, then obviously they would direct that a species of slave-men be produced and the consequences of it are not difficult to imagine, If in reply it be said that the new species of men would pursue higher values, then we ought to ask if without knowing these values and also without knowing how these values may be cultivated, it is possible to manufacture this kind of man. If the ability to choose be denied to the manufactured men, then the question of their being morally responsible will not arise, and those who choose to create morally responsible creatures would stand morally condemned. Recent developments in the science of linguistics suggest that language has apriori structures, which are the basic structures of man. And so it is reasonable to argue with Kant that moral consciousness has its own apriori structures. In other words, however strong may be the arguments against a fixed human nature, they do not convince us that it may be to totally changed that the laws of logic, the principles at the back of sciences, the creative elements of human nature, articulating themselves in art and literature, the moral laws, indeed everything that makes a man a man proper will cease to hold or exist. .

We may say that the virtues of which Mr Churchill speaks would not cease to be, though, they may be veiled. And we should always keep ourselves ready to tear the veil that we may thoughtlessly have covered them with. In other words, they are imperishable, as their perishing would imply perishing of men, but they cannot assert themselves strongly and confidently if we are not active to keep them shining. Increase in our scientific and technological knowledge is covering them with thicker veil and we should always be alert and resolve and act firmly to tear those veils and this requires that we understand what science exactly is, and that the abuse of science is a consequence of our failure to understand science.

CONCEPTS OF SCIENCE AND SAINTLINESS

Analysis of the Concept of Science I have stated more than once that the crisis of this age is a moral and spiritual one and that this is a consequence of our failure to understand the nature of science. And I have also stated that we are accustomed to think of science as ethically neutral. Now in this section I intend to analyse the concept of science and to make the analysis relevant to our purpose. We would seek an answer to the question how the current notion that science is ethically neutral has gained such a wide acceptance and also to the question as to what the limitations of this notion are.

Modern science dates back to the seventeenth century, and what idea the builders of science had about its nature may be gathered from Dialogues on the Two Systems of the World. Here we find Galileo and his adversaries at hopeless cross-purposes. Galileo holds that· an event is scientifically explained when it is shown 'how' it occurred. But his adversary Simpliceus thinks that to explain an event we should demonstrate 'why' it occurs. This distinction between the' 'how' and the 'why' approach is precisely the distinction between the scientific approach to nature and the medieval largely theological approach to nature and to define our attitude to science as well as saintliness we should dwell on it a little.

So let us have a look at the scientific attitude. Nature is a mighty stream of events with many currents and cross-currents. The events occur. Occurrence of every event is preceded as well as followed by events. The scientist has first of all to identify his objects. This identification "is usually called classification. It is the first step in his explanation of nature. But classification does not lift science much above common sense. The next step that a scientist takes is one of finding a relation between events. Thus the scientist will be able to say 'why' a thing happens when it happens and 'how' it happens as it happens. It may be mentioned that this is done by us at the common sense level. But the scientific way of doing it is qualitatively different. It is very careful and precise, and the concept of cause is given a thorough over-hauling. According to Aristotelian doctrine, there are four kinds of causes, viz, material, formal, efficient and final. We are here interested in the final cause, which is represented by 'why' in a question. If we hold that it is relevant even in the cases, where things are not made or manufactured by man, we would then have at the back of our mind the theological idea that even objects like mountains have their authors. And in our daily life we often think in this way, particularly when we raise the question. Who has created the Universe? And there comes the stock answer: 'Not any human or finite being,but God, the infinite being-a being with purpose, reason and intelligence'. Thus we compare the work of reason in the deductive sciences and the role of purpose in our goal-seeking acts-put the two together and arrive at the mighty speculative conclusion that the Universe has been created by an infinite being with reason and purpose, and so to account for the occurrence of every phenomenon we should relate it with this infinite reason and so also to determine what purpose it serves. To a man at this level of thinking a 'why-question' is a question about final cause. But the builders of science did not think that it was within the competence of science to attack a question of this type. Indeed, it holds that the pursuit of such questions is not rewarding. Thus Newton did not make any attempt to answer the question why there is gravitation, but being a believer in God he did not declare that such a question is meaningless. So also Galilee was both a scientist and a believer. But Bacon banished the concept of final cause from the logic of the sciences. The distinction between the non-consideration of final cause while tackling science and the elimination of it from all rational discourse is very thin and so the search for final cause has been treated as foolish and anthropomorphic. This is at the basis of the conflict between science and religion, a conflict that has lasted for three centuries and one is thought to be suffering from intellectual dyspepsia if one cherishes the hope that it may be satisfactorily resolved. So when we are making an attempt to show that the attempt at being scientific at the cost of being saintly or similarly the attempt at being saintly at the cost of being scientific is suicidal; we ought to say a word or two on how the conflict is essentially the outcome of the failure to assess the role of final cause in human reflection.

The belief that a supreme intelligence created and sustained the Universe or was articulating itself in nature, was at the basis of our sense of values, particularly of moral values for centuries. Thus if we take the disvalues- sin, crime and the morally wrong, we would see that they were not carefully distinguished before. Thus to tell a lie or not to keep one's promise, is morally wrong, is a crime, is a sinful act. Indeed, to the question why one should not tell a lie the traditional answer was- not that it offends our moral intuition, but that God forbade it. The doubter was thought to be the devil's disciple. In short, the moral imperatives were not considered to be categorical but hypothetical. True, some inspired persons spoke of virtue for the sake of virtue, or that virtue was its own reward. But such persons were thought to be dangerous. At least it was a common belief that such a creed would be ruinous to the poor mortals, the beings of flesh. Accordingly, thus the idea of final cause being ruled out or God being dethroned the sense of moral values collapsed or as was put 'God is dead, everything is permitted'.

.Now if our thirst for knowledge is strong, our moral nature or the thirst for moral values is not weak. So our moral nature revolted against progress of science. What the outcome of this revolt would have been if there were free and fair fight is anybody's guess. Actually the fight was not free and fair. For, progress of science brought along with it the power to control nature, which had as a consequence economic and political power. We tried to make easy compromises, recommended science on the week days of action and religion on the Sundays of rest. Easy compromises do not last. They introduce more diseases than they cure. So we are today at the edge of a precipice. Anyway, the motto 'knowledge for the sake of knowledge' ceased to work. It was replaced by knowledge for the sake of power, and the claim which is still made these days by some that science is ethically neutral sounds hollow, if not hypocritical.

Some existentialists of today declare that the most depressing thing about contemporary culture is that after inventing machines man has not only become slave of them, but take them as their ideal. Not a saint or a wise man or a hero is the ideal of our age but a machine in good order. Our institutions should run as a machine does; our society, our family, or everyday life, indeed everything should be modelled after machines. No wonder we are at the edge of a precipice.

Kantian concept of moral teleology presents both science and saintliness in a new light. Thus, science assumes that nature is intelligible. This implies that nature is embediment of intelligence-a purpose. The purpose is the emergence of man, the moral man, a being endowed with good will and sense of values. This moral is autonomous and so categorical. In other words. it is not deduced from divine will. Moral commands are not hypothetical. To go behind the appearance of diversity and dive deep into the mighty current of unity is not an intellectual task.

Shri Ramakrishna Paramahansa was not a University don or doctor. Nor was he a commentator. Indeed, he was not a man of learning at all. And not by interpreting the scriptures he realized the oneness of all religions. He did it by his living. Such living is denied to most of us. We hardly ever feel the pang of separation from the ultimate one. It is not for us to understand God first then refine and cultivate our sense of values. We shoulz start from it and think in consonance with it.

Now the question arises, if a man does not believe in God, is he therefore immoral. We are accustomed to the affirmative answer to this question. But this is not a satisfactory answer. Either moral will is autonomous or virtue for the sake of virtue is a statement without meaning. No lucid thinker can assert them in the same breath. Besides, if one intends to deduce moral statements from religious statements one undertakes an impossible logical task. So it is extremely unwise to deny the autonomy of moral consciousness or sense of values. This is a pint that 'was seen through and through by the wise men of India. Indeed, it was Indian wisdom not to subordinate moral sense to belief in God. The word 'saint' stands for yogi and their denotation overlaps. Yoga consists in chittabritti nirodha, arresting of the mental states and processes. We may put it also as controlling all the disturbing and rebelling forces of human nature. Thus the relation between a belief in God and being saintly is not either necessary or sufficient. It is not necessary; as one may be saintly without knowing God. It is not sufficient as one may believe in God but may not be saintly. Saintliness forms the essence of human nature. That it is at the back of the pursuit of science would be evident from the following observation of T H Huxley, one of the fathers of modern science.

'Science seems to teach to me in the highest and strongest manner the great Truth which is embodied in the Christian conception of entire surrender to the will of God. Sit down before fact as a little child, be prepared to give up every pre-conceived notion, follow humbly wherever and to whatsoever abysses Nature leads or you shall learn nothing. I have only begun to learn content and peace of mind since I have resolved at all risks to do this.'

In our way of putting it, the scientific attitude is also the attitude of the saint, Duty for the sake of duty is its motto. The motto is not cognitive. It is moral. And accordingly it is a pursuit of values arranged hierarchically, the highest value being freedom from or conquering of passions and appetites. It is Nirlipta as Gita puts it.

To bring this point home we may refer to the life and teachings of Gautama, the Buddha. He has been held by some as an atheist by others as an agnostic and by many he has been identified with God or held as an incarnation of God. All such descriptions are incomplete and hence false. If one reads his teachings between the lines one cannot fail to find out that he was the follower of the middle path. He did not think it wholesome to 'waste time and energy on metaphysical, subtlties. Nor did he think that a man is essentially an animal. The true being of man was his moral being. The same is true of Vardhamana, the founder of the Jain faith. Indeed the Indian philosophical systems are by and large reluctant to expound subtle philosophical theories on the nature of God. Their chief concern lay in propounding the ephemeral character of the worldly values. Their attitude was that these values were not of the highest order, the highest value being complete realization of the self, the proper being of man. Anyway, a critical analysis of the scientific attitude makes it apparent that it is not opposed to saintliness. Indeed, a scientist who is not nirlipta or sthitadhi fails both as a man and as a scientist. He is a danger to the human 'race as he is a danger to himself. He suffers from dissociation. His is a self divided. The present crisis is largely due to the cultivation of science by persons suffering from dissociation.

Analysis of the Concept of Saintliness

The concept of science has been analysed in detail. The concept of saintliness has also been incidentally analysed. We need not, therefore, dwell on it at length. We often think that a saint is other-worldly. It is a mistake. This distinction between this-worldly and otherworldly is a false distinction. The real distinction is between higher and lower values. Again a statement 'that to be a saint one should repudiate the world of sense and science' rests on misunderstanding of saintliness.

It is true that a saint is one who renounces. But renunciation means pursuit of higher values. Gautama, the Buddha, Acharyya Sankara were sannyasins. They practised great renunciation. But their social consciousness was as strong as that of anyone. Indeed, it was stronger and more responsible. It has never been their contention that everyone should renounce the world and live the life of a recluse. It is the question of being an adhikari.

It is unfortunate that some weak-minded escapists parade themselves as saints. The one to one correspondence of which the Yogins speak between the microcosm and macrocosm is sufficient to establish the contention that they do not dichotomise the world into this and other. Bhuh, Bhavah, Sva etc, the seven lokas of which they speak are said to be designations of the different structures of the human organism as well as of the different stages of the progress in spiritual life.Similarly they assert that there is an essential identity between self (atman and the absolute (Brahman).

Saints had profound knowledge not only of the spiritual nature of man but also of his bodily nature. One example should suffice. The Asanas, on which they gave so much stress are indicative of the knowledge they had of the human body and its functions. It is becoming more and more fashionable everyday .to take Yogic exercises. This tendency is based upon the demonstrated values of these exercises. But what I should like to underline is that the bodily exercises are not for the sake of the body but for the healthy' mind in a healthy body. We often flock to the ashramas of some saint. who trains us to meditate and we learn how to meditate and feel reconciled. But here also we do not take care to see that meditation is not for the sake of the body or the social and commercial self only. It nourishes them. But it is for the development of the total self, the self in a state of equilibrium, unruffled by passions and desires. It should be noted, and it cannot be over emphasized, how deep was the knowledge of the saints about the nature and function of the body, the food that one should take, the kind of life that one should live, the nature and function' of mind and also the order of values.

The popular idea that a Yogin is concerned with the supernatural rests on a confusion. The confusion is a deep-seated one in that the distinction between the natural and the supernatural is widely held and while the science is allotted the natural; to the saint is allotted the supernatural. This distinction is false. There is no distinction between the natural and the supernatural. Science may have its limits and this is due to the method it uses. But beyond science is not beyond nature. The real distinction is between the natural and the artificial. The deviant, be he a scientist or a saint is artificial. Therefore, saintliness properly understood is not antithetical to science;

Every object or situation is complex. We may never be sure that we have observed it fully, and so every statement is corrigible. Hence science would patiently collect facts, observe their repeatability, would ascertain their unconditionality before it would make an assertion. In other words, in science we would not say that we know unless we are in a position to demonstrate. Science involves patient observation, pairing, comparing, grouping, finding out invariable relations and many such things. One cannot be a scientist unless one learns to be methodical, viz, how to identify the area of study, how to isolate it from the irrelevant, how to proceed step by step from what follows from something to what follows from something else. A scientist is a man, who applies this method almost effortlessly. It is a habit with him. The method is comparable to the method of the saint. Yama, Niyama and Pranayama, etc, form a part of his way of life. Now, if we consider the cultivation of saintliness in our daily life, we will see that the scientific habit, the scientific way of meeting a situation helps us in developing saintliness in us. In science, we proceed methodically in a disciplined way, from the demonstrated to the not yet demonstrated, from the known to the not yet known, from the clear to the not yet clear and the journey from 'from' to 'to' is always careful. When in our daily life, we adopt this attitude to the identification of values and also in the realisation of them, we just promote saintliness in us. To put it differently, science is an intellectual discipline. But this isnot disciplining the intellect alone. Intellect is a part of our nature. If the other parts remain indisciplined one cannot discipline one's intellect. Besides, to discipline one's intellect one should see that one's wish is not the father of one's thought, that one is not guided by bias and prejudices, that emotion does not have charge of one's intellect. So disciplining intellect is acquiring a character. It is picking up a way ofliving. While we train the intellect we train the mind, the entire psycho-physical complex. Now this training may be put to service to explore nature, to obtain knowledge and information. But if we stop there, we do not do justice to the training. If we use it only to know and control nature, we are not valuing it properly. It should be used to identify the values and to guide us in living up to the values. So a mind trained up in science becomes free from superstitions, and biased thinking, and in its attempt to live up to the values it helps us in developing our saintly nature effectively and almost effortlessly. Science properly understood and cultivated informs saintliness.

SCIENCE AND SAINTLINESS

From what has been said above, it is clear that one can be neither a successful nor a meaningful scientist, unless one has a sense of values, unless one knows how to distinguish between higher and lower values. And so we may say that we are properly scientific if and only if we are saintly as well.

The converse of this proposition is also true. For values do not float in empty space. They are grounded in the factual. Distinguishing between higher and lower values is a barren exercise if it is not guided by a sense of realities, a knowledge of actual state of affairs. In other words, the ideal is the ideal to be translated in to the actual and the actual actualises if and only if it is infused with the ideal. To oppose ideal to the actual is to make the ideal empty and the actual dirty. In concreto the ideal and the actual are not opposed.

So we would conclude that one may be saintly if and only if one is scientific, and that one may be scientific if and only if one is saintly.

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Why Are We Here ? — A Scientific and Philosophical Study on Human Existence'

Shri R N Joshi, *Fellow*

INTRODUCTION

I have been asked to deliver the Tenth Nidhu Bhushan Memorial Lecture. The pleasure and privilege are mine. I thank the authorities for giving me this honour. It is my good fortu ne that I got a chance to pay my humble homage to the memory of late Shri Nidhu Bhushan. This Lecture offers an opportunity for me to organize my stray thoughts inspired by and collected from a thousand sources. I claim no originality, but have an open mind and have a desire to understand the 'how' of science and the 'why' of philosophy-the two aspects on which my lecture is based.

I am addressing engineers who are essentially practical persons with a scientific base actively engaged in putting scientific principles and advancements to the service and comforts of the society. I am particularly glad that I am giving this Lecture on the auspicious banks of the river Sabarmati, where Mahatmaji carried out his valuable experiments with the truth, and where Vikram Sarabhai got inspiration for scientific achievements.

The purpose ofthis exercise is to locate the position of man in the vast arena of existence; to try to thi nk ou t the meaning of this big game if there be any such meaning; whether man has any significant role to play; what are his potentialities?; what and how he is discharging himself? ; and to try to see if the study indicates any line of action.

THE UNIVERSE

To start with, I like to say a few words about the size of the Universe. According to science, universe though vast is finite. Long distances are measured in light years. A light year is the distance travelled by light in one year at its speed on 186000 miles per sec. The size of the universe is estimated at 21.2 billion light years.

We live on the earth. one of the planets of the solar system. Man is a tiny speck on the globe which itself would vanish into oblivion in comparison with the universe. I would suggest a relationship between the size of the earth and the universe, being expressed for convenience of memorization by the word 'STESSGAUN,' meaning grain of sand, height of tree, diameter of the earth, diameter of the solar system, diameter of the Galaxy and diameter of the universe being in geometrical proportion with about a million as a multiplying factor. There are billions and billions of planets which are located in zones of comparable temperatures as of the earth. Apart from the feasibility of any different forms of life than those perceived on our planet, it would be hazardous to say with certainty that- ours is the only planet to beget life. With the limitations of our knowledge it is proposed to limit this study to the framework of life on our planet the earth.

It is seen that situations on this planet, the earth, have been meticulously planned to sustain and support life. This indicates that life may not be a mere accident.

LIFE VS NON-LIFE

The origin of life on earth is estimated to have been two billion years old. Nothing is known as to how life originated once upon a time, what preceded such an event, and whether the process except by reproduction, repeated any other time, or continues in some form even now.

The most significant aspect of a living body is that it consists of an equipment and an operator. The equipment is a sort of meshanism built of material composed of highly complex organic substances different from the inorganic compositions of the inanimate world. Life commences when the operator takes charge of the equipment and terminates when he leaves it. The functioning of the equipment is rhythmic in character involving several cyclic and periodic operations and events such as hunger, sleep, pulsation of beart, breath, secretion of glands and sex. Science concerns itself more with the equipment of life; and philosophy with the operator thereof.

Again matter in non-life is in itself well organized and involves regular rhythmic movements of its minute constituents and obeys well-defined laws of stress-strain relationship, fatigue, expansion and contraction and so on, which should indicate in matter some lower level of life than total deadliness. Non-life has no free will. Life introduces free will which goes on developing with higher forms of life. Mobility in animals indicates more freedom. Man is endowed with full freedom of thought and action. God is great and His creation vast; yet man has freedom of thought even beyond the great God and his vast creation.

DISTINCTIVE ROLE OF MAN

The greatest attribute of man as distinct from the rest of the animate world is that he is endowed with a kilo and a half of grey matter-his brain-which works as an automatic computer and even something more. The design and working of this highly complex human organ, so compact and protected is a mystery of mysteries.

Another speciality of man in the animal kingdom is the use of hands. The advancement of man has been possible through the coordinated and complementary functioning between thought and action through the brain and the hands; his two distinctive features.

Advancement of man has further been possible through the activity of communication he has so ably developed. He developed language to decipher and label emotions, objects and ideas by words and action symbols with tremendous amount of nicety and subtlety. He has been able to extend the scope of his senses many-many-fold beyond that of the bare senses with the help of instruments devised by him. Thus through a 200 in telescope he can see stars 8 000 millions of light years away.

Apart from the qualities of his brain, use of hands, extended use of senses and art of communication, the real attributes of man characterising him are his developed mind and soul, conscience and sub-concience, sense of art and culture, and quest for knowledge and deeper understanding. Man is endowed with a superb equipment and is a superb 'operator' and, therefore, he has excellent life opportunities. The anotomical and physiological evolution must only be a superficial exposition of the finer equipment of man and must be a part of the larger and total evolution.

Man is on a progressive march; and his equipment looks to be tuning itself. It is likely that if the present model of equipment of man has the potentiality of larger attainments to fit in the scheme of larger evolution the model may well continue, of course, with due tuning and balancing. It is too early to judge if the present equipment is good enough for the purpose. If it is not, further evolutionary processes would be inevitable.

Man has two roles of play-the animals role and the superanimal role. This often creates a conflict in him. He has to play the animal role successfully enough to safeguard himself and his species and to keep him fit and healthy to be able to play the superanimal role with distinction. The superanimal role is an end in itself the main objective of mankind, the animal role a means to an end. With his superanimal urge for understanding and realization he can establish unison in apparently diverse observations and can resolve all conflicts. It is for man to find out the via media between his two seemingly conflicting roles-the animal and the superanimal. How far man has been doing it will be examined in what follows.

PROBE OF WESTERN THINKER

Study of sciences has demonstrably brought out universality of behaviour of objects irrespective ot variation in time, place and the observer. The scientist is however acutely conscious of his limitations. The scientists search in the vast space and his probe in the analysis of a n atom has yielded bounties of information. Yet he finds that depth of bis information is proportionate to the efficacy of his observations and that he is nowhere near the totality of knowledge. The scientist gets baffled and the scientist-philosopher gets frustrated. Analysis leads nowhere but deepens the problem.

An important aspect of investigation has been the relationship of matter, body and mind and to locate the seat of animation in the human body. The man of science has some knowledge of how senses function and of the external processes of perception. We have some knowledge as to the regions of the brain to carry out the assigned functions. Something is known about the biochemical processes controlling pituary and other glands producing either the tears of sorrow, the blush on the cheeks, or fountaining the mother's milk. But neither science nor the science-based philosophy has a glimpse of the operator behind. The biochemical processes are just the modus operandi of how things are brought about. It is not the master operandi. It is not the crown that rules nor the pen that writes. These are but the transferred epithets. The real ruler and writer are different. Who is it that really perceives through the senses. Who is it that experiences the joy or the sorrow? Where is he seated? The scientist has no knowledge of the operator proper and none as to who prompts the operator.

APPROACH OF ORIENTAL SEERS

Whatever the stage of scientific knowledge and its application to daily life that prevailed in the Vedic and Upanishadic times, some of the oriental seers of that age had obtained considerable insight in metaphysical matters on which hardly anything is known to the modern science. It is often supposed that science of the present day was obviously beyond the reach of mankind in those days. Obscurity regarding the exact knowledge prevailing at that time is due to the fact that the knowledge through the scriptures is allegorical in form. It is however likely that some scientific truths in astronomy were known to them and here are a few illustrations. The sun god washighly respected and the number 108 is considered holy in relation to the sun. It cannot be just coincidence that the diameter of the sun is 864 000 miles, ie 108 times the equatorial diameter of the earth. That the earth was round was known in the Vedic times some 10 000 years ago. It was allegorically suggested to be resting on Shesha, the cobra. The philosophic interpretation is that the earth has sprung from a very insignificantly small fraction of the Absolute. A science based interpretation could be that the earth is supported on or is balanced by the rest of the universe. Still another instance may be the concept of Brahrna's day covering 4.32 billion years which is not far different than the age of earth as ascertained by modern science. There are descriptions indicating the manner of creation of the cosmos such as it started with the nebula or ocean of gases which seems to have some relevance in the light of modern theories on the subject. Several evidences indicate that at least some scientific truths were known to the Rishies of old. As to how they acquired this knowledge is anybody's guess. In passing it might be mentioned that depth of thinking and preciseness of expression had reached a fairly high level in those days as can be judged from the fact that there are more than hundred words for water to indicate the propriety of its source and user, and there are different words to indicate several decimals upto billion-billions.

It can be said with certainty that the old oriental seers did not give much value to physical sciences of the mortal world and possibly did not utilize them much in securing comforts of daily life as in the modern age. They had however given considerable emphasis on metaphysical aspects. All manifest and non-manifest arise from the Absolute, the one beyond description and beyond the perception of human senses, for the Absolute is beyond limitations of time and space. It is at His Will and His sacrifice that the formless has taken form and split into infinite forms, different and distinct. The ultimate reality is one, though the learned describe it in various ways. The entire diversity has a core of unity, since unity has created the diversity. One in the many is the corollory of many from the one. The Absolute is involved in the entire creation. The process of evolution continues. It is what is involved that gets involved. Matter, life and mind are the stages of evolution.

Man with his tremendous potentialities is at the helm of the evolutionary process. Realization of the Absolute by man is the object of the evolution. Realization is possible through the concerted effort by man coupled with the grace from the Almighty. He is liberal in offering all graces and hence it is the self-effort of man which is all important to put in the necessary self-effort, self purification is needed, starting with healthy body, alertness of mind, and clarity of thought.

AN APPRAISAL

In the history of mankind, to the extent it is known or can be guessed, during the last 10000 years, say, we have had towering personalities who can be said to have had the insight of the mysteries of existence and had an approach to the ultimate reality. If this is so, a question arises if the mankind is really progressing, or otherwise; in fact degenerating. In respect of physical sciences and its application in fulfilling the daily needs and looking to the comforts of man, the progress is unquestionable. But is man making any significant contribution in quenching the human thirst for the knowledge of the ultimate? Man is an animal and something more. It is the quantum and proportion of 'something more' that makes the quality of man as distinct from an animal. Man has a belly in ornmon with the animal, and he has to fill it to keep the machine going. But man's special privilege and distinctive attributes are his mind, his capacities for experiencing and his latent thirst for the knowledge of the ultimate reality. If he uses his brain merely for filling his belly, he is only living as a polished animal, not as a man. His manness is to be judged from his attainments in human qualities. Is man really progressing in his "manness'?

If it is considered that in the age of ancient Rishies man had made substantial spiritual progress; it had to be said that mankind could not retain the acquired treasure. The sublimating principle of the dictum of 'work without attachment' was lost sight of in subsequent period, and people tended towards inaction. Surrender to the Master turned into renunciation of life. Realization or communion with the ultimate developed into the concept of freedom from the repetitive cycle oflife and death, therey contributing to the negative approach to life. Life came to be considered as a tyranny and as a most dreaded punishment, Life presented a serious and gloomy look. In the misconstrued pursuit of transcendental fulfilment and happiness, charms and relish in enjoying several experiences in life, individual as well social, were denied, taking all existence as illusory. It appears that the consequent escapism and denial led to a dark period wherein spiritualism was forgotten and material prosperity shunned.

In the West, on the other hand, materialism has been n trial. Industrial revolution gave it a great fillip. Man has not only produced a machine but has converted himself into a machine, losing all individuality and insiration. In his life-long preoccupation in earning a living in most cases and, amassing more and more wealth in others, man has no time nor the peace of mind f r any superanimal attainments. Enjoyment of worldy pleasures of 'eat, drink and be merry type, to whatever extent they are available to a man do not seem to satisfy him. Aquisition of such illusory pleasures gives him no satisfaction but makes him more greedy. The drink paradoxically enhances the thirst. Man leads life of acute stresses and strains. He has conflicts all round-conflicts with nature, conflicts with his fellow being and conflict with his inner self. In trying to catch happiness far himself he gets engulfed in deep worries and sorrows. To forget his sorrows he tries tranquillizers. His mind is the abode of envy, His vision is distorted. His action is croocked. Devoid of idealism, he manage; viceous acts, multiplies, and defends them. The pollution also extends to his physical surroundings; air is foul, water contaminated, food adulterated. Mankind seems to be at the turning point. Man derives no happiness from materialism. The outcome is total frustration.

Rapid advances in science seems to be having toxic side effects on the society. Man has become intoxicated with the pride of his treasure 'catch' of inventions and discoveries, which stand in sharp contrast not only with the achievements of animal world but also with the history of mankind. Man has brought about the explosion of sciences during the century. He took wings and started flying. He has exploded atom bombs and released tremendous amount of energy by breaking open the tiny atom. He sent his messengers and has planted his flag on the moon. He thinks of snatching away the nature's privilege h the allotment of sex to the newborn. He might succeed in rearing a baby in a test tube. He is on way to produce a living cell, however, tiny. The discovery howsoever creditable for man is actually tantamount to uncovering life in matter. Though the discoveries have turned some scientists in to philosophers and have made them humble with the realization of the tremendous potentialities of nature, science has converted the outlook of an average man and has given him a feeling that he has captured nature. He seems to be in a mood to challenge the creator. This is changing his manner of life. To him life becomes artificial. Sex usurps the seat of love. Culture is obsolete. Art is the whim of the whi misical. Idealism is the way of the faddist. Visionary is con sidered an idiot. God has been expelled from the scene. Well, the dog is barking at its master. The child rebukes at its parents. Man finds nature as worthless, even enernical.

The West has captured the world and drags it westward. The world has been benefitted by the advances in science. Bounties of experimental results and their far reaching inferences are available to the thinking mind to enable some understanding of the reality. The greatest service of science to mankind is in fighting natural calamities; in protecting man from all odds; providing him food, shelter and clothing; and in offering him all comforts. If science is filtered of its toxic effects on mankind it can be a great tool indeed for man to fulfil not only his animal needs but his super-animal attainments as well.

In the materialistic attitudeto life as we have atpresent, man deals with transactions in which if one gains the other loses. Happiness and sorrow look to be two sides of the same coin. Man splits into classes, one against the other- the employer versus the employee, the landlord versus the tenant, the merchant versus the customer and the haves against the have-riots. In such cases, conflicts are inevitable. Happiness for all is an impossibility. This is so because of the short sighted and selfish attitude of the participants. For want of a better word I will call this attitude as 'bipolar attitude', which tries to set the interest on the one part as against the interest of the other part. It would be advisable to change the attitude to a unifying attitude in which both the participants stand to get happiness out of the deal. Unifying approach in certain respects is not unknown in-our life. Thus love begets love, goodness inspires goodness, symphony enriches the harmony, one torch enkindles another, wisdom spreads wisdom. It will be possible for man to replace the bipolar attitude by a unifying attitude adopting super-animal approach. He has to learn to live with a larger and benevolent mind and with a wider and illumined self-interest leading to unison and no conflicts. In his daily life and in carrying out several transactions he should accentuate basically on points of common interest.rather than a few advantages he would apparently gain for himself by manoeuvring some tricks. This approach would humanise man's life andwould bring happiness for the mankind.

Man is exposed to pain and suffering-both physical and mental. This often leads him to attribute pain to some harassing forces. The physical pain is nature's method of timely intimation offaults in body functioning and asking for attention and correction which otherwise would lead to more serious disorders. The. modus operandi of such timely signals in the working of so complex a machinery as the human body, exposed to variable situations both natural and man-made-ismore to be welcomed and admired than to be complained against. His mental suffering may be due to loss of possessions or due to loss in financial transactions he might have undertaken. These could be reduced to the minimum if mankind adopts unipolar approach in life as suggested earlier. Sometimes man gets disturbed by obvious injustice in life wherein the vicious prosper and the virtuous suffer. The fact of the wide matter is that man's understanding is based on patchy and incomplete information from the short portion of the spectrum of the total knowledge. Not much is known to either science or philosophy of nature's administration of justice or of the face of an individual electron (without free will) or of man (with his free will) in certain situations. What they know is only the general trend. In any case it may be generalisedithat mental suffering of man on whatever account could be amply toned down with a proper frame of mind.

CONCLUSION

I now like to' draw some conclusions from this study. It was mentioned earlier that though the universe is vast and extensive, our knowledge regarding it is limited and hence this study was restricted to the life on earth. After having made a general survey of life on earth and more particularly of human existence it is observed that man has been quite active on the dynamic wheels of science, but he very much lacks direction and even basic understanding regarding the purpose of creation and the objective of evolution, a process of continuous unfolding of life forms and events. His advancement has been lopsided and unbalanced. Anyway, whatever be the process of evolution in terms of development of matter, life, mind, and anything further, whether man with his present limitations can reach the desired objective and if any creature with superhuman powers would be coming on the scene, it is pretty sure that such happenings would be a long drawn process and would need an extensive period of time. It looks therefore desirable for us to lay down a still lesser framework, wherein we can get an answer to what we can do here and now, so long as the line of action for the lesser framework does not go counter to that in the larger framework and is consistent with it. Understanding of the ultimate reality and the realisation of the Absolute is supposed to lead a person to eternal. fulfilment and happiness ever afterwards; both in this life and any other. As against this objective in a larger framework, we could very well consider life-long happiness of a type which will not fade or wither away as our immediate objective in the lesser framework. We can also ask for such pure happiness for one and all. It is hoped that this objective would be universally acceptable irrespective of differences of caste and creeds, or religious faiths, or political ideologies. In fact it may be considered to be the highest common factor of all religions, the bridge between earth and heaven. Achieving this objective of real and life-long happiness for one and all is not that easy. Raselus wandered the world over in search of a happy man and could not meet one. Tn the modern world things look to have worsened. We have to ask ourselves as to what is it that would make one fully happy and also what is it that would make everybody in this world equally happy.

For a man to be happy it is necessary that his animal needs are met within a reasonable way and his superanimal expectations fulfilled. He needs food, clothing and shelter. Man needs protection against natural calamities and perils such as floods, draughts, earthquakes and thelike which, as we know from our sad experience, can cause tremendous hardship to mankind. Man is to be guarded against diseases and epidemics, and should be enabled to lead a healthy, active and alert life. He has to be supplied with the needs of a community life. He must be furnished with recreation facilities. He must have venues to develop and express art and culture as an important feature of his extended skill in conimunication and self expression. These needs of man, I would caII, are his earthly needs. Satisfaction of these needs is necessary to make a person happy. But happiness demands much more than thesatisfaction of these basic earthly needs of man.

Whereas pleasure and comfort are the attributes of senses, happiness is the attribute of mind. Pleasure and happiness are not synonyms in that sense, nor are the suffering and happiness antonyms. Comforts may make a person happy for a short while. True happiness comes from within; it is inspired. A balanced mind and clarity of thought can make one happy. Fulfilment of super-animal urge in man brings him happiness. Dedicated selfless service to humanity is the royal path to achieve the objective of pure and life-long happiness for mankind. Leading an active life with unipolar attitude in mutual interest is indicated as the directive for our action here and now. This would amount to action without attachment and without desire to earn something for oneself, taking care that this does not degenerate into inaction. Life must remain dynamic but one might weII consider all actions being offered to the fact of the Almighty. The consequent effect would be to raise the potential of happiness all round, and not to have happiness in some quarter being cancelled by unhappiness in another. This can lead to the realization of our immediate objectives in the lesser framework wherein happiness would be pure and real, life-long and all pervading.

Ishopanishad has given a directive in connection with the larger framework as

विद्यां च अविद्यां च यस्तद् वेद उभयं सह ।
अविद्यया मृत्युं तीर्त्वा विद्ययांऽमृतम् अश्नुते ॥

This means one who has understood both spiritual knowledge and non-spiritual knowledge severally and jointly would overcome death through non-spiritual knowledge and would acquire immortality through spiritual knowledge. (This translation may be taken as a liberal one as the word Avidya is interpretated in different ways, sometimes as non-knowledge, sometimes as Karma as against spiritual knowledge). On similar lines, I take the liberty of stating the objective for the lesser framework as

विज्ञान तत्वविद्यां च यस्तद् वेद उभयं सह ।
विज्ञानेन मृत्युंतीर्त्वा विद्यया सुखम् अश्नुते ॥

one who studies both science and philosophy separately and in relation to each other, would enable man to overcome mortal or earthly problems (like the ones to fight natural calamities, disease etc) with the help of science and would make one happy through the knowledge about oneself in relation to the creation.

The universe exhibits infinite manifestation of the becoming and consists of multiple differentiations and distinctions. As such it poses a highly complex differential equation. By mathematical analogy the solution indicated is one of integration. For the highly complex philosophical problem of understanding the meaning of multiple existence, the indicated solution is synthesis. In tune with both of these indications what is suggested herein is the integral approach. It is not the matter alone that matters; the spirit matters even more. Mind the spirit; mind the body as well for it embodies the spirit. Take care of the equipment. Also take care of the operator and the control organization. Take due care of bodily needs which forms a necessary part of the final objective of spiritual fulfilment. Combine the qualities of head and heart. The brain offers powerful tools and the heart provides motivation and gives proper direction. Tuned combination of head and heart can lead man to perfection. As an immediate step to reach the final objective man' can attain pure and lifelong happiness for his entire race through the prudent combination of science and philosophy. Man is on right path if he synthesizes science and philosophy.

I thank you once again for giving me an opportunity to present to you some of my thoughts.

I conclude my lecture with the prayer:

Let All be happy and free from disease
Let all look at others with regard and respect and
Let no one cause pain to anybody else
Let silence, Peace and Tranquility pervade the entire world.

सवेय सुखिनः सन्तु सर्वे सन्तु निरामयाः ।
सर्वें मद्राणि पश्यन्तु मा कश्चित् दुःखमाप्नुयात् ।।
ॐ शांतिः । शांतिः ।। शांतिः ।।।

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Humanism — the Base Fabric of the Engineer's Ethics

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INTRODUCTION

I am extremely happy to have this privilege of paying my respectful tribute to (he great scientist, philosopher and humanist, the late Nidhu Bhushan Chatterjee, in whose memory this series of lectures has been instituted. I have had the privilege of being present at most of the previous lectures in this series; these lectures have covered various aspects of science, technology, humanism, Ruman existence, quality of life, philosophy, spiritualism and, in fact, have gone on to discuss the universe itself; They covered these subjects in a perspective of great depth, and if I indulge myself in dealing with such basic aspects, it would mean traversing the same areas which have already been covered in the earlier lectures, though in different words, and in any case with less competence and knowledge compared to my predecessors. I have therefore chosen for this lecture the theme "Humanism-the Base Fabric of the Engineer's Ethics." Under the title of 'Humanism', I propose to stress that the meaningless rituals, superstitions and dogmas that appear to have become parts of what is commonly practised as spiritualism should give place to philosophy, truism and service.

The following remarks that E F Schumacher made in the context of Appropriate Technology are relevant in pointing out that technology has a human face:

> 'What is the meaning of democracy, freedom, human dignity, standard of living, self-realization, fulfilment? Is it a matter of goods or of people? Of course, it is a matter of people. But people can be themselves only in small comprehensible groups. Therefore, we must learn to think in terms of an articulated structure that can cope with a multiplicity of small-scale units. If economic thinking cannot grasp this, it is useless. If it cannot get beyond its vast abstractions, the national income, the rate of growth, capital/output ratio, inputoutput analysis, labour-mobility, capital accumulation; if it cannot get beyond all these and make contact with tbe human realities of poverty, frustration, alienation, despair, breakdown, crime, escapism, stress, congestion, ugliness, and spi ritual death, then let us scrap economics and start afresh.' .

Stating that it is the intrusion of human freedom and responsibility that makes economics metaphysically different from physics, and that all real human problems arise from the antinomy of order and freedom, Schumacher calls for a blending of both in a healthy business corporation:

> 'Without order, planning, predictability, central control, accountancy, instructions to the underlings, obedience, discipline-without the magnanimity of disorder, the happy abandon, the entrepreneurship venturing into the unknown and incalculable, without the risk and the gamble, the creative imagination rushing in where bureaucratic angels fear to tread-without these, life is a mockery and a disgrace.'

The need today is for us to see the human face in engineering.

WHO IS AN ENGINEER?

An engineer is basically a man, a, social being; a few years of his professional learning does not make him either a sub-or a super-human and in the discharge of his professional responsibilities, he has not only to keep in view that he himself is a man, but also is applying his professional knowledge for the sake of man and through the man. Thus he has tobe all the time vigilant of the human face of his profession.

Chamber's Twentieth Century Dictionary defines an engineer as 'one who designs or makes engines or machinery; an officer who manages a ship's engines; one who constructs or manages military works and engines; and the last definition amongst the lot is that an engine driver is an engineer'. This is the state of affairs of material knowledge. So we cannot blame the youngsters if they so define an engineer. It is therefore important for us to educate those concerned as to what an engineer's responsibilities are and how an en~ineer should be defined.

An engineer has acquired certain skills and knowledge and competence with the help of the society for serving the very same society by providing it goods and services. He converts natural resources into concrete goods and purposeful services; in so doing, he makes use of science and technology and gives due weightage to all other parameters-economic, social and even political. It is wrong for us to think that politics is out of an engineer's realm of decision-making. I have heard this often; even this morning sornebody'mentioned to me that a technical decision was taken to put up a dam at a place' A', whereas the political decision was to put up the dam at a place 'B'; and so, naturally, the engineer was upset about the matter. Well, I would only say that perhaps he did not take into account the question that there is a political parameter. If he had, he would have perhaps greater courage and conviction to argue his proposal. Notwithstanding the fact that we are out of active political working, notwithstanding the fact that we are not occupying the chairs of bureaucracy or dealing with the files, we must realize that we are a conceptual part of it in carrying out our professional responsibilities. It is then only that we will be able to define the whole engineer. A prudent engineer, specially at high level, has necessarily to take into account the social and political aspects in addition to the technical ones. Building up or generation of wealth and the productivity of the processes related thereto cannot be conceived to be independent of the policies of distribution of wealth. Towards this end, the engineer is also very much concerned with the social ends and the distribution policies relating to the results of his toil.

NEEDS OF OUR SOCIETY

Having defined the engineer and having related his task to the needs of the society, we must know what these needs are. Naturally we all know the needs of man; the needs of man are: food, clothing, shelter and environment. But today when we ask ourselves a question that by providing enough food, by providing enough clothing and enough shelter and the proper environment, is the human being satisfied? We find he is not. On the other hand, the more the material wants are fulfilled we find him less satisfied as an individual. For example, take some of the advanced countries; they aspired for all the material benefits that a human being could possibly do in the availing environments, they got it; they went step by step and in the course found there was perhaps nothing more they could materially aspire for. So their minds went elsewhere. Without going into whether they turned towards hippyism or perverted yoga or even narcotics, the fact is that mere satisfaction of these needs alone, though they are basic indeed, cannot be taken as having met all the needs of the individual. Why? Because an individual is a part of the society and the needs of the society are different. The human being in a society has certain other responsibilities to look after; there are certain other things he expects from the society. What is it that he expects from the society to which he belongs? This is the point which is beyond the individual needs. We except good people, proper discipline, laudable ideals, selfless help to others, happy relations with others, willingness to lead a whole life, willingness to lead a life compatible with the social context and having what is called an altogetherness. One may call all these as being responsive to the national or societal cause. If this expectation is satisfied then we have satisfied the needs of the society in which we live. Therefore, we must now examine what the needs of the society are.

No doubt, the society needs many things; one of them being the fulfilment of the tasks before us and until those tasks are brought to a minimum level-which will be a changing one with time-we have to move in that direction. If we take our own country we have a number of major and challenging tasks before us. We have to increase our food production from 120 mt to 175 mt; in order to provide this we have to increase the area to be irrigated from 38 million hectares to 65 million hectares within reasonable plans. We have also to provide agricultural implements, necessary fertilizers, etc. We have then the responsibility of providing shelter to the millions of shelterless. It is estimated that we need a minimum of 100 m dwelling units at present in order to meet the demands of housing for all our brethren, we need to put up about 150 m units by the turn of the century whereas the present rate at which we are building is only about 0.3 million units per year.

Then we come to the question of laying half a million kilometres of roads to improve communications-both urban and rural. Energy output has to be increased from 86 billion kWh to 180 billion kWh. Again, in terms of basic measures, we need to increase the steel production from 9 m tonnes to 15 m tonnes, cement production from about 19 m tonnes to 32 m tonnes and so on. When we compare ourselves with some of the advanced countries, we find that even these great advances we may make will only marginally improve our position. For example, for a population of about 600 m people in India, we are having the per capita production of wheat flour at 3 kg, against 54 kg in the USA, 36 kg in Japan, 49 kg in Sweden and 50 kg in Germany. Similarly, in the case of steel, we are producing about 15 kg per capita against 554 kg in the USA, 548 kg in the USSR and 957 kg in Japan and so on; power, by way of electricity, we are producing 143 kWh per capita against 9 800 kWh in the USA, 4 200 kWh in the USSR and 9 200 kWh in Sweden. In the case of cement, we are producing about 31 kgper capita as against 485 kg in the USSR, which is the largest cement producing country in the world, 596 kg in Japan, 285 kg in the USA and 330 kg in Sweden. All this indicates that before we are able to think of our societal responsibility, we have to have the basic needs of living. It is here that we have to see and draw somewhere a reasonable line as to what are the basic needs in the present generation or the present times and, in order to meet these basic needs, how engineers can discharge their responsibility in filling these gaps keeping in view that employment generation and rural development are basic components of the strategy.

There is yet another way in which we can think of the basic needs. As we have said, one Bhakra Dam could have perhaps electrified the whole of Switzerland at the time it was put up, and so in a country with a large population almost anything expressed inper capita terms will give figures at a very low level. Therefore we take the principle of Socrates; somebody having the agony of misery went to Socrates, and said, 'Sir, I am a very miserable man. I pray, you solve my misery'. So it is said that Socrates replied him, 'Alright, my dear friend, give me all your misery; but on one condition. I will ask all the people to pool their miseries, and divide it equally among all so that you may have an equal share'. When he saw what this equal share would be, he said, 'Sir, I would rather be with my original misery than the equal share'.

When we come to the per capita aspect in our country, the position is somewhat similar but conversely. When we take the world production and divide it by the world population and assess India's standing against the average, we find that in power production we have 9 % of the world average per capita, which means that even to reach the world's average, we have to make up by 91 %. In steel our performance is 8% and in cement 17% of the world average. India is basically an agricultural country with 80 % of the population engaged in agriculture but our food production is only around 40 % of the world average. This figure I had collected sometime back; there may be a slight variation but this is the situation where we stand.

When we talk of humanism, we must remember we are living in a condition of such wants. If somebody becomes inefficient in working, there is no point in implanting our foreign knowledge in the situation. There may be a farmer who gets nourishing food, has a good house, all amenities, television set, motor car and all the luxuries of life and he may work hard during the eight hours he works. But if our farmer does not have one square meal a day, can you expect him to work hard? It is this point that we have to see basically. What I am appealing to you and submitting is that we have to go a step beyond seeing the pure material aspect of how his conduct has been at a given moment, that is, to the causes for this. When we examine this, we find that the reasons are not very difficult for us to find. For example, I am sure, we all would have come across the case of an irritant official in the office, the basic casue for whose irritation we find, on a cool and close examination, perhaps a quarrel he might have had with his wife. Why did he quarrel with his wife? May be the milk did not come in the morning and he could not take his cup of coffee! Whatever the reasons may be, the situation under which we are today living is to be seen from this background of wants. Therefore, any action we take and any decision we make have to be made keeping in our minds the background ofthe environment in which this society or this part of the human society is living. Our approach and strategy therefore must be appropriate to that particular situation.

The next point is the complexities that an engineer has to face in his profession. Almost every activity of the society today has a substantial engineering component and, therefore, it is not merely from the point of view of demanding importance to the engineer that I am talking but from the point of view of realizing that we are a part of making a success of almost every endeavour before the society. In order to look into the problems of poor people who live below the level of poverty, it is not enough for us to realize their wants or the environments in which they are working. We must acquire a confidence to deliver the goods. How do we deliver the goods? I will give you one small instance. Long ago in 1951, I was in charge of a survey team for a water supply scheme covering an area of approximately 6200 km^2 in Rajasthan. During the course of the survey work we came across some villages where the survey party was not allowed to go in. So I went myself and discussed with the chief of one of the villages. He told me that his farm was 'Laxmi' and he would not allow people to enter in with shoes on. I also found they were afraid that their land might be taken away after this kind of surveys. It took me some time in convincing him about the nature of my job and my respect for their sentiments. I had to make him comfortable that he was not at all going to be advorsely affected by the scheme. He then showed me a place where construction of -a small dam would be useful to the villagers. To my great surprise, when I asked our team to do a brief survey, we found the villagers knew the survey data better than what our instrument could show. We found that the site shown by the farmer was the right place for storage of water and supply to the fields. The people were prepared to give their labour and we did put up a small bund about 20 m long to supply water to their lands. We.could not have ignored these needs which were met with at practically no cost.We respected the views of the people and we wanted their cooperation. So, we could on our part get along with our job and they were left happy. The point, therefore, we have to appreciate here is that we can deliver the goods even under adverse circumstances, but confidence is necessary. And it is this confidence that is most important in our beingable to reduce poverty if not banish it totally.

NOBILITY OF THE PROFESSION

This confidence arises out of certain ethical norms in our profession and for that matter ethical norms are necessary for every human being in every activity. We appreciate that the profession that we have come to occupy either by choice or by circumstances is a noble profession. You know that we have the privilege of being a class of people who have been trained only to look at the progress of the society and to identify our interest with the progress of the society. In a lighter vein it is said that a politician makes his living on the ignorance of the society, a doctor on the diseases in the society, a lawyer on the quarrels of the society; and an engineer on the progress of the society, An engineer has no other way of making his living. He must think of progress. If he does not work out more schemes to come up, the engineer will have no job. Undoubtedly, the politician, the doctor, the lawyer, the engineer and so on, all are important, each of them being an essential limb of a healthy nation; each of them is very much required in his own sphere. But the fact is that we are proud of the noble profession that we have taken upon ourselves. And it is possible for us to reach the highest goals that any saffron robed man may aspire for provided we are true to our profession-based on ethical norms which themselves are based on humanism. This is the message that we have to have in our life day in and day out. Ifwe miss this message we will not be true to ourselves and it is then, we are failing not only ourselves but the society in which we are living. This message comes from a series of norms which we have to consider.

BASIC ETHICAL NORMS

Self Imposed Discipline

What are the things which form the basic points of the ethical norms? First is the discipline-a self-imposed one instead of an externally imposed one. I am talking this as a part of a conviction. It is known that any amount of imposed discipline is not going to be what a self-imposed discipline would bring in. I must say if we all examine truely our conscience, we find that self-discipline is far lacking than what it ought to be. This is not a matter of light-heartedness. We have a serious responsibility.

Simple Living

The second point is simplicity. This might be conventionally called simple living and high thinking.

Service to Others Main Aim

Service should be our motto, that is, how I can serve my neighbour, another person. Here I am reminded of the prayer meetings of Mahatma Gandhi where one of the shlokas recited was:

Nathvaham Kama ye Rajyam
Na Swargam Na Punarbhavam
Kama ye Dukha Taptanam
Praninam Arthi Nashanam

That is, Oh Lord, I do not desire a kingdom, I do not desire the pleasures of heaven nor do I desire to be free from the bondage of birth and rebirth but I very much desire to see the cause of misery in those engrossed in it completely destroyed.

This may look like more a sermon but I do want to submit to you that unless we make some of these basic tenets as part of our life, a part of our blood stream, it is not likely that we will be able to achieve much success.

Professional Competence

The next point of importance which I have come across very often during my 27 years of professional career relates to the evils that the lack of professional competence often breeds. The lack of necessary knowledge and competence to do the work sometimes comes in the way of our being able to deliver the goods. It is here that professional institutions like The Institution of Engineers (India) are doing great service to the engineering community whereby we have an opportunity to up-date our knowledge and be professionally competent. Therefore, nothing can replace competence. Here I am reminded of the motto of the Mysore University from which I first graduated *Na hi gnyanen sadrisham*. Nothing is higher than knowledge.

Sometimes when knowledge is lacking other forces occupy that place and it is only to avoid the other forces that we must have to make sure that we have the competence. When I am using the word 'competence' I would like to submit that it is not possible for all of us to have all knowledge in the world-not even an infinitesimal fraction of it but what is important is we must recognize knowledge wherever it is and in whatever form it is. In other words, in an organization if I am the top man, I am not the custodian of the intellectual property of all the people who work with me. The intellectual properties exist and work in their own environments and parameters but I have a certain responsibility to direct them and harness them towards the given goal. The competence is in seeing that whatever are the inputs required to do a job are acquired-may be through a handbook, may be through a mental machinery, may be through a thinking machinery, may be through help of others, horizontally or vertically; whatever it is. So it is.this that I am meaning when I am talking of necessary knowledge and competence. It is not uncommon for us to find in our own profession, some of the senior people avoid competent young people and have their No 2 the duddest possible man so that they could shine against the dud. This is the basic philosophy which is against the tenet of a competent man. I would like to shine better than a diamond. I would like to have the largest caratted diamond next to me if! want to shine and not to shine against the dusty old corroded piece of iron. This is the competence that we have to develop and that courage must have to come.

Unattached Action

The next requirement as part of our basic ethical norms is what we have been talking and we all know is the unattached action. Of course, one can give a talk on this itself, but I do not want to make a talk on Bhagwad Gita or its philosophy but the unattached action which is reflected in the very commonly known shlokas from the Gita.

Karmanyevadhikaraste ma paleshu kadachana and

Yogasthah kuru karmani sangam tyaktva dhananjaya
Siddyasiddhyoh samo bhutva, samatvam yoga ucyate

When I was going through the Granth Sahib, I found

Seva karat hoye naha kami
Tis ko hot parapat Swami

He realizes the Lord (the Truth) who serves without any desire for remuneration. In every religious scripture this is said. But what does it mean? It does not mean that we have to refrain from action but we have to be detached to the fruits of that action in the sense ofrelating it to ones own self but relating it to the society to which we are serving.

Internal and External Integrity

The next requirement is integrity. We all know what we mean by integrity, but there is something more than the usually accepted meanings; that is, what are called external integrity and internal integrity. External integrity is what we know and we all generally talk about. But internal integrity is another matter which has to form a part of our lives; In our own reasoning and thinking it is important for us to appreciate that we have to maintain a sense of integrity. I am here reminded of Prof Magnel, a very famous author ofa book on prestressed concrete. I happened to hear his lecture just a few days before he died after 40 years of a brilliant career. As you may know, his books and his papers are known to be highly mathematical and highly complicated. I had a lot of difficulty in following him and so I was carrying a very wrong impression of the man that he was a very complicated man. But when I happened to attend his lecture in Belgium, the last sentence he said was 'Friends, my 40 years of professional experience has taught me one thing: nothing can replace engineering judgement in engineering jobs'. Today we know that youngsters come with all sorts offormulae half-baked,half-cooked orraw cooked. They feel bad if we do not accept them. But the fact remains that till today nobody has found an alternate to engineering judgement. Similarly, there is no alternate to internal integrity. It is an experience; it is not something that we can say. The internal integrity depends upon our inner reasoning, our inner personal principles and so on.

Aim Towards Perfection

The next point is our approach to perfection in whatever we do. It is not uncommon for us to find that at the same cost and in the same time with the same people we could do better. This unfortunately has gone out of our cult and I am sorry that this is a very sad state of affair in out present situation. Here I would like to quote from the Gita: Yogah Karmashu Kaushalam. In fact ten years ago the first publication that I brought out from the institute which I have the privilege of heading, I put this shloka on the back cover of the book; not because I wanted to give any publicity that we knew Sanskrit or something of Gita, but because I wanted to make every possible endeavour to make an institution give attention to this aspect and show that it is possible for us to aim at perfection in everything we do. And it is said perfection is unity with God, no matter whether I am doing the largest and the most complicated planning for a country or whether I am doing sweeping of a lavatory. There is something like perfection and that is God, that is Truth and that is the Highest.

In our profession we must ask ourselves a question whether what we have done is perfect.lt does not take any more time or any more effort to do a perfect job. It only require an attitude of mind and similarly in our jobs we can do hundred and one things which are better than what they are, no matter how low or how high the job we are doing. This type of an attitude is another component of the basic norm for our ethics.

Adaptability to Changes

The next one is adaptability to changes; changes in environment. And in fact change is the law of nature. Change must take place. Every day and every moment changes are taking place in environment, in the people, in the circumstances, etc. Changes do take place depending on the position we occupy, the age in which we are and so on. The norms we adopted for our wives, we change by the time our daughters grow. Therefore, the adaptability to change is an important component in forming these norms.

CODE OF ETHICS OF IE(I)

Having got this I would now like to refer to a few points in our own Code of Ethics of the Institution of Engineers (India). Keeping these norms in view I think a review of our own code of ethics is necessary because I find that an indepth reading of our code of ethics gives me an impression that we are branding ourselves being lower than being humanistic. I will just read out one or two points. Code 4 says, ‘A Corporate Member will express an opinion only when it is founded on adequate knowledge and honest conviction if he is serving as a witness before a court or commission’. Why only as a witness before a court or commission? When I express an opinion to my Minister I talk precisely the same as I talk to my assistant. This is the conviction we want and this must be based on sound knowledge. The exception or a special case made in the code should be generalized as part of our life.

Another example (Code 13): 'A Corporate Member will not associate in work with an engineer who does not conform to ethical practices'. Why only an engineer? Why should an engineer associate himself with a politician who does not have ethical practices? This requires certain amount of courage.

Similarly, there are other codes as well which I do not want to go on listing here. But I would only like to submit that it is time we looked on these ethics with a view to basing them on humanism since humanism is of an unchangeable value. The norms arising out of this humanism, change with time, change with the environment, change with social structure; yet humanism is eternal; it is the base fabric on which you can have different paintings conforming to certain rules of the game, as you may call it.

CONCLUSION

Good Triumphs over Evil

Finally, I would like to quote two distinctly different types of people. One is once an American Presidential candidate, Wendell Wilkie, a politician and the other is Albert Einstein, a scientist of highest eminence. Wendell Wilkie in his book 'One World' has said: 'World contains men but the tragedy is all men are not human.' Imbalance of this nature is the evil. We celebrate Diwali and Dussehra and the philosophy behind these festivals is not merely burning lights or invoking the goddesses, but it is the significance of the fight between good and evil, which is a constant principle of nature. But it is one triumph over evil that takes place now and then. Wilkie said that when humans integrate, humanism becomes actuality and when humanism becomes more dominant, good wins over evil. Therefore, it is a question of our making man a human. It is not possible that we convert all of them into humans, whether it be in the engineering profession or in the administrative services or in the law or the medical profession. What we can do is only to have the norms applicable to ourselves.

Sympathetic Understanding of Experience

Einstein said towards the advanced part his research that humanism is above material aspects. 'The supreme task of the physicist is to arrive at those universal elementary Jaws from which the cosmos can be built up. There is no logical path to these laws; only intuition resting on sympathetic understanding of experience can reach them'. Let us therefore realize that even for the brightest and the most intellectual brains we have, our rationality and reasoning have some components outside them which we have to sympathetically view and understand the experience. So the experience is what the richness of our culture and heritage gives us. When I am talking of culture let me also quote Mathew Arnold, the famous philosopher poet. He defined culture as 'The pursuit of our total perfection, by means of getting to know, on all the matters which most concern us, the best which has been thought and said in the world'. In fact, this is *Yogah Karmashu Kaushalam*.

Freedom from Fear

The next question is under what circumstances can I think of all the humanistic things? Is it when I am peaceful, when I have had my food, when I am having all happy circumstances-that I think of humanism. But where is humanism when I am under terribly shocked condition? The real human quality will come under the most adverse circumstances. It is not under normal circumstances that we see the real human qualities, it is at a time when the greatest challenge is before us that we react and show our inner selves. I have seen people run away from complex problems and in doing so they adopt unethical practices because they find the circumstances are complicated. We ought to perform a duty even under the most complex challenges that many come before us. We have to face them and face them on the basis of these ethical norms which are based on humanism. We can acquire the courage or strength to face these through freedom from fear. I am sure you will agree with me that when we all analyse the many events of our lives we find we have acted in a certain manner at that point of time out of a fear. What was the fear? We had a fear either that we may lose a job or something may be written in our confidential report or may be something else adverse would happen. This fear can be banished only by following ethics based on humanism as I have indicated earlier, and we stick to the truth. Let us not think of apriest as an agent to reach God. Mother Theresa, in her long number of I years ofhuman service, said that she saw and sees Christ in every suffering human being. Let us see humanism in every engineering task that we have undertaken. Let us make our conscience the agent to reach the higher glory and let us not at any time detract from the call of conscience. The true happiness, joy and contentment comes from true service for which the engineering profession gives abundant opportunities.

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Science, Technology and Philosophy'

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INTRODUCTION

I take this opportuntiy to thank the Council of the Institution for doing me the honour in asking me to give The Nidhu Bhushan Memorial Lecture today. I had not the fortune to know either Shri Nidhu Bhushan Chatterjee or his illustrious son, Dr G P Chatterjee who instituted this Lecture in his father's memory, but looking at the stipulation of the subject, I have a suspicion that Dr Chatterjee must have developed a regard for the older school of thinking and must have considered that his success in life was due to his father's influence in the impressionable age of his life. I am reminded of somewhat similar feeling myself. My father had only a vernacular education and had learnt Sanskrit as a tradional accomplishment but was deeply interested in knowing what the modern sciences had to say about many things discussed in the scriptures. At that time I never thought there was anything common between the two modes of thinking-partly due to lack of knowledge of advances in modern physics at that time and partly lack of understanding of the symbolic language. Age and maturity have changed the situation since. I believe that Dr Chatterjee's interest in spiritualism and philosophy must have arisen out of respect for the wisdom of his father. I am, therefore, making an attempt to correlate some ideas from science and philosophy.

SCIENCE, TECHNOLOGY AND PHILOSOPHY

More and more people are beginning to believe that science and technology can achieve a complete mastery over the universe around us. This is due to spectacular achievements of scientific thought and development of complex technology. Landing on other planets, utilizing the energy of the atom, development of stage miniaturization of mechanical and electrical machines to be accommodated in very small volumes, etc, has naturally increased one's faith in the progress in this direction and led one to imagine that as knowledge and capabilities increase, one can almost reach a stage where man would be the master of the universe. Strange as it sounds, the ancient philosophical thought 'I am the ultimate (अहं ब्रम्होस्मि)' almost describes this state of man's knowledge. How far this parallelism is justifiable in the background of our present knowledge of science and technology, as well as basic thought of our philosophy, is the theme of my talk.

In the beginning, 1 must confess and admit. I am no expert in all these branches of knowledge, but for my study I have taken recourse to the best known. Authorities in these subjects. Physical sciences and achievements in civil, mechanical and electrical engineering are very closely connected. Science, in the general sense, is knowledge ascertained by observation and experiment, critically tested, systematized and brought under general principles. These principles can then be utilized for technical application by taking into account the peculiar conditions of the case in consideration with its limitations. In abstract form where such scientific principles are formed into mathematical models, the special circumstances in application appear as boundary conditions or determination of constants. It must be remembered that such laws originate from observation of phenomena round us through our senses and power of reasoning.

For technical purpose, an approximation of scientific theories, where qualities of very minor importance are not taken into account, is sufficient. This is perfectly justifiable as the focus is on the utility of the application for man, and the things that would be affectd by the inexactitude are of no consequence to him. For instance, the simple laws of motion of solids without any resistance are good enough to technology to estimate power required to move objects by minimizing friction or resistance of any other type to move towards the limiting case of zero resistance. The Euclidian geometry is good enough for our purposes of many engineering problems where dimensions do not approach the sizes of the major portion of our globe. If we were to discard the concept of a plane surface, parallelism or the properties of a triangle, machines of common use would be an impossibility. However, refinement in scientific information and methods of predicting results by use of mathematical aids continue, as the need arises in many applications, where previously ignored parameters become important, Structures such as buildings, roads, bridges differ from structures of aeroplanes, high speed machines, scientific instruments, etc. The materials used differ in homogeneity, strength qualities and supervision exercised during fabrication. The engineer allows sufficient margin in using their strength as well as estimating the stress they would be put to in actual use. If experience shows that some of these assumptions are not sufficient, a change is introduced to cope with the new information and further sophistication takes place in the design and fabrication.

The desire of man to get the best out of the materials used for his purpose starts scientific inquiry into the relationship of strength of the material and its inner structure. A simple example is the method of heat treatment of certain alloys to increase its mechanical strength. This was possible by the study of the aggregates of grains of the constituents in different condition of existence at different temperatures and by choosing '1 suitable condition where the grain size of the material become finer and closer to each other and then freezing them in that state by suddenly lowering its temperature.

Another example of how requirements made scientists to develop their theories where more properties of the material were taken into account is the laws of hydrostatic and hydrodynamics. In the beginning, when dealing with substances like water and oil, the fluid was considered incompressible but had other inertial qualities as well as viscosity. The neglect of the viscous property served many applications and the deviation of the actual result from the calculated one was accounted for by use of suitable constants. In the case of lighter fluids like air or gases, the viscosity was small but compressibility was obvious. However, the neglect of compressibility was shown to have a negligible effect at fairly low speeds that were involved in many applications in the early days. The mathematical model of a fluid where shearing forces do not exist but is compressible introduced a new parameter, namely, the speed of sound (or the speed of a small pressure disturbance) in the fluid concerned. The phenomena changed abruptly at this speed and what was happening to body moving below this speed, was completely different from the picture presented at speeds above this limit.

A difficulty with the concept of mathematical fluid was that it failed to explain the phenomenon of resistance offered to the body and the appearance of a complex pattern of vortices observed in the wake. Obviously the ideal fluid theory was insufficient for the purpose.

The use of viscous terms in dealing with a real phenomenon, made difficulties in solving the problem in most cases as known mathematical methods could not give a close solution. The development of the boundary laver theory for fluids of small viscosity, where a small laver in which viscous forces are predominant was separated from the rest of the region and treated separately baving same conditions at the boundary of separation. This method was able to explain and estimate the drag, separation of flow. Stalling of airfoils, etc. This method was equally applicable to the subsonic and supersonic cases. Recardina the fluid as a continuum was also to be discarded in regions where the pressure was negligible and the mean free path of the molecules was considerable.

Obviously the method used had to be of a statistical nature. where impact of discrete molecules with the body in question had to be considered according to mechanics of sol id particles. In the realm of physical sciences, the concepts of space and time underwent considerable change. The rational method used - in scientific thought found it difficult to define these concepts. For instance, a symbolic equation of type f (A) = f (B) assumes that f (B) = f (A) where A and B are parameters considered. If one of these consists of derivatives with respect of time, we assume reversal of time is not possible. The concept of time as intuitively understood assumes that it runs in one direction ina unique way and does not return. In our normal experience, within the span of time in which we live, the assumed property of time seems to be in conformity with our experience and helps us to analyse and estimate the effects in changing phenomena. Not only time and space but progress in modern physics has changed our ideas about matter and the sequence of cause and effect. If every event has a cause, which itself is an event, then it must also have a cause, and the event considered mav be cause of its effect. It can run into infinite series of events on either side of the event considered, However, if we limit the field of our investigation to the physical phenomena occurring in our every day life, this does not seem to produce very serious difficulties.

The desire to tind out the nature of ultimate reality either by using rational methods as in science or intuitive as in philosophy, has compelled us to change our concepts about matter, space and time, which an average person finds it difficult to imagine or describe accurately in words. It was assumed that nature could be described objectively if one knew all the forces acting on things and their position in space, without reference to the observer, in our case a conscious human being. This method has succeeded in most cases where classical mechanics was used to obtain solutions. The electromagnetic phenomenon was the first which could not be described correctly by this method. The concept of electrical and maznet ic field had to be introduced. The property of space, capable of producing a force is known as a field, This field is created by an electrical charge and the force it produces on another charge brought in this space.

The development of 'Theory of Relativity' and 'Atomic Physics' Changed our ideas based on classical mechanics where space andtimewere taken to be absolute, the matter was considered to consist of elementary solid particles and all natural phenomena were strictly according to the law of cause and effect.

It would be a difficult task to consider these theories in detail in a talk of this type but we could consider some of the results of these theories.

The mass is nothing but a form of energy as is known from the famous equation

$$E = mc^2$$

where c is the velocity of light. The force of gravity, according to Einstein, has the effect of curving space and time, which will make normal Euclidian geometry invalid in such a curved space. The discovery of X-rays and other radioactive substances shows that atoms of such substances undergo a transformation by giving out various kinds of radiations.

The representation of an atom on the model of planets, represented the chemical properties by the number of electrons in the atom. In trying to explain many results in terms of normal methods. the physicist met with a number of paradoxes. This had to be accepted as in the quantum theory of representing the small particles as abstract entities having a duality depending on the observers attitude. For example, light can be in the form of electromagnetic waves or particles, the photons.

All this led to a set of opposite concepts such as the presence of a particle at a given place. It is not present at a given place nor absent; it does not change its position nor does it remain at rest. What really describes it is its probability pattern, which gives it a tendency of existence at a given place.

In the words of W Thirling in 'Building Bricks of Material', 'The outlook on matter has changed from particles to concept of field. The presence of matter is a disturbance of the perfect state of the field at that place. There is no unique law to describe forces between elementary particles. Order and symmetry must be sought in the under lying field'. This leads 10 the concept of fieldas a continuum present everywhere in space and yet when considering the particle Las to be visualized as having a discrete granular structure. In other words, the concept of space and matter. form and emptiness seem to get united and resemble the philosophical thought 'What is form is emptiness and what is emptiness is form.'

The classical concept of a repulsive force between two similarly changed particles such as two electrons, seems to be not a correct description. Neither of the particles experiences a force on approach but merely interacts with exchange of photons, and the force is nothing but a gross effect of this exchange of photons.

Researches in exploring the sub-atomic region, has shown that the matter has a dynamic nature, as the consituents of atoms; the sub-atomic particles do not exist as isolated entities but in the form of exchange of particles. In fact the gross concept of a particle as a tiny grain of matter disappears. Most of the unstable particles have an extremely small life, in terms of our concept of time but viewed from a point where their movement is considered in terms of their size, it is quite large. This corresponds to the idea of the Mandukya Upanishad regarding three different cases of consciousness, namely, 'Wakeful state', 'Dream state' and 'Deep sleep state' where the time scale changes from the normal in the first to very minute in the second and to almost zero in the third.

I would now consider a few thoughts from the Upanisliadic philosophy. First of all, the language used to describe ultimate reality is in terms of paradoxes and correspon.ds to the similar situation existing in describing sub-atomic processes. Normal language to convey thoughts depends on common concepts which are restricted by our three-dimensional existence in space and irreversible concept of time. The concept of a combined space-time does not give us a mental picture as ordinary processes do, and as such has to be conveyed by a symbolic abstract representation in mathematical form. A common description can only be done by attributing contradictory properties. existing simultaneously.

अणोरणियान् महतो महीयान् (क०)

(minuter than the minute and still greater grcaicst.)

आसीनो दूरं व्रजती सयनो याति स्रर्वतः
कस्तं महाभदं देवं मदन्यो ज्ञातुभर्हति ।। (क०)

(Sitting still goes far, sleeping goes everywhere. It is both full of joy and without it, who else but me deserves to know that effulgent being)

In order to grasp such ideas which lie outside our common experience one has to describe them by a simile.

आत्मानं रथिनं विद्धि शरीरं रथमेवतु ।
बुद्धिंतु साराभे विद्धि मनः प्रग्रभेव च ।। (क०)

(Know Atman as lord of the chariot, the body as the chariot, the intellect as the driver and the mind as the reign)

Regarding relative consciousness of time, consider the description of reality in Mandukya Upanishad.

ओम् इतिएतद् अक्षरमिदं सर्वं तस्य उपव्याख्यानं भूतं
भवद्भविष्यदिति सर्वं ओंकार एव। यत् अन्यत् त्रिकालातीतं
तदपि ओंकार एव ॥

('Om' -this syllable is everything. The past. the present, the future are all its description, anythi ng that transcends the normal temporal concept is also 'Om')

This is illustrated by splitting the symbol 'Om' in four parts, namely, अ, ऊ, अं and ओं (as whole). Each represents a different state of consciousness. The first three states are familiar to every human being while the fourth state transcends by the realization of the ultimate reality.

1. जागरित स्थांनो वहि-प्रज्ञ:

In a wakeful state, one is conscious of the outside world and represents our normal experience.

2. स्वप्न स्थानोऽन्तर: प्रज्ञ:

In a dream state. one is conscious of thincs that are within him and bear no relation to happenings regardmg time sequence, rorrn or rationality of cause and effect.

Medical science tells us that mostly the dream lasts a few moments and yet the cxper iencer in a vivid dream lives through a number of years and experiences strange things such as one's own death. To put it in another way, the concept of t rrne has changed and shortened as the life of an unstable atomic particle.

3. यत्न सुप्तो न किंचन कामं कामयते न कंचन स्वप्नं पश्यति तत् सुप्तं ।

(In deep sleep the sleeper desires nothing. sees no dreams.)

Here the time has approached zero but not quite, as on waking up he is able to contact his wakeful experiences again.

4. नान्तप्रज्ञं नविहि: प्रज्ञं नोभयत: प्रज्ञं न प्रज्ञानधनं न प्रज्ञं नाप्रज्ञं ॥

This is a combination of the first three stages of consciousness and is verv difficult to describe in words. One is not conscious of outside world or inside world. he is neither conscious nor unconscious. neither enlightened nor ignorant. This state of consciousness can be considered to be so minute as to penetrate everything as well as so great as to occupy the cosmos. A scientist who is convinced that the fundamental constituent of matter are certain sub-atomic particles, and they alone are the reality as far as all objects he deals with in his life, and yet he neither eats the glass and throws away water. However, this knowledge changes his emotional outlook on the world around him. All our feelings of love, hate, fear, etc, presuppose that the observer in each case is separate from the objects which create these emotional reactions in him. For the feeling of fear there has to be an outside agency which will do harm to the person. If this separateness disappears, one is truely fearless. This state of consciousness is described in Bhagvad Geeta:

यथाभूतपृथग्भावं एकस्थं अनुपश्यति ।
तथ एवच विस्तरं ब्रह्म संपद्यते तथा ॥

When one begins to realize that there is one common clement in all things. then one's outlook is expanded enough to realize the ultimate reality.

I have tried to compare the SImilarity of thought in science and philosophy when attempting to understand ultimate reality. In the normal life of the philosopher or the scientist, limited approximations which govern our existence are adequate and sufficient. It is not necessary to have up-to-date knowledge of modern physics to differentiate between tasty food from putrid one, nor it is necessary to realise the nature of the ultimate to live in peace and harmony with fellow beings. Our concepts though not absolutely correct, are useful in a limited sense. The search for absolute reality is inherent in man and, in a sense, an attempt to understand himself which forms a part of the universe. Whatever method we choose, we approach the same reality. It is an asymptotic approach to the same unimaginable end.

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Technology in a Crisis of Confidence

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I deem it a great honour bestowed on me to be invited to deliver the 13th Nidhu Bhushan Memorial Lecture at 1he 59th Annual Convention of the Institution' of Engineers. A grateful son has perpetuated the memory of his father by an endowment for memorial lectures ou a very wide field which covers science, spiritualism, philosophy and engineering and I have chosen for my talk 'Technology in a Crisis of Confidence' which encompasses all these disciplines and will challenge all our intellectual endowments for a solution. As engineers who arc expected by society to deliver 'the goods', we have a great social responsibility because we will be judged ultimately by the impact we make on human welfare. We are very much concerned with the question whether this impact has been of the right type and dimension. This assessment raises many questions whether there is any antithesis between technological progress and human happiness; whether there are reasons to believe as anti-technologists say, that there has been a decline, or, as optimists say, an increase in welfare as a result of the phenomenal material progress that technology has I made possible. The answer involves criteria which raise issues of great analytical and philosophical complexity and these can vary with the philosophical outlook of the person who is called upon to answer such questions.

The power that technology has bestowed on the engineers is so vast that all the evils in society tend to be ascribed to the so-called errors of technology.

A BALANCE SHEET OF TECHNOLOGY

Let us start at the more mundane level and prepare a balance sheet of credits and debits of technological advancement. The engineers, as representatives of technology, are put in the dock and called upon to account for the debits in the social account, without much credit for the credit entries. It has been well said that medicine has given mankind health, that humanities have given mankind pleasure and that technology has given mankind the time to enjoy both. We have tamed, rather enslaved, the five elements and we are no longer overawed by their turbulence or intractability, we lord over them rather than their lording over us. We have, over a span of hundred years (from 1850 to 1950), had our golden age of spectacular achievements and social benefaction. We have annihilated distances not only over this planet, but also between the planets. We have spanned rivers, walked up to the tallest of mountains, landed on the moon, harnessed the terrific energies of wind. water and the sun. and at a lower level we have reduced the demands on animal and human labour, and with the advancement of the computer even the demands on the human brain. Let us note the chief items on the credit side of the balance sheet.

(1) One can perhaps claim that man's greatest achievements over the last 200 years had been in the medical field.The result is a doubling of the life-span as compared to that of our grandfathers. Rapid and creditable strides had been made in the sphere of preventive medicine, health care and surgery. We can now hope to live and work not only for longer number of years but also sit back in good health and rest for longer number of years at the end of the career. '

(2) We have so improved the agricultural methods that enough food can be produced to feed the whole world. In a developed country the productivity per man in agriculture has risen so much that while in 1930one man could produce for ten persons, today one can produce enough for fifty-fivepersons. To this end technology has conferred benefits on agriculture through improvement in the quality of the soil, regulated supply of water, of insecticides, improvement in plant nutrients and in the quality of seeds. The historical developments in the past warrant us to believe that we can through a more integrated and ecologically-oriented approach to agriculture and through food processing and distribution face the problem of food supplies confidently, especially when we remember that food can come not only from land but from the still unexploited sources in the plant, animal and marine kingdoms.

(3) The importance of energy is equivalent only to that of food and the main uses of energy are for transport, for home, industry and agriculture. With the growth' of population and the diversification of the uses of energy, the demands will be many times the level of the present. We can no longer depend upon coal and mineral oil, We have begun to look more to gas for the home and we are even making efforts to exploit solar energy, but the most important source of the future is likely to be nuclear energy. Even with regard to this, there is a fear that even the supply of natural uranium might get exhausted in Course of time. There are also unfounded fears that

time may come when the world may feel the shortage of supply of many of the essential metals. This cells for a new technology, since we have only a limited earth space to exploit for energy or metals. While this is a hallenge to the engineers and technologists of the future, to date technology has not allowed the world to starve for energy.

Then, turning to the debit side, the entries include:

(1) environmental pollution,

(2) international mal-distribution of technical knowhow and the consequent gap in material welfare,

(3) the threat of total annihilation by radio-activity and nuclear weapons,

(4) the exhaustion of the world's natural resources, and

(5) according to some, especially the anti-technology group, the destruction of the quality of life-noise, dirt, ugly matchbox buildings, monotonous jobs, keeping up with the Joneses leading to despair and neurosis.

It is not necessary to explain in detail these items on the debit side. We do know the several sources from which the pollution of our environment is taking place. Almost all industrial processes are capable of polluting the atmosphere.

The exhaustion of world's natural resources is a real serious problem. Man removes from earth 2 000 million tons of petroleum in a year, 600 million tons of iron, 4 million tons of lead and each of these has taken hundreds or thousands of million years to form.

While the proportion of the people in the developed countries achieving a higher standard of life has risen in the first-half of the century, the technological gap in the less-developed countries has widened the material gap between those well off industrially developed countries and the others. At least, half of the world suffers from serious threats of hunger or malnutrition. Lastly radioactivity resulting from nuclear experiments are already posing a serious problem.

What is the net balance-debit or credit? The present fashion is to say that the debit balance has definitely begun to outweigh the credit balance and they have put technology in the dock.

TECHNOLOGY IN THE DOCK

But one interesting phenomenon is that technology has a mate in this distressing predicament. That mate is economics and it is not surprising to have economics as a sharer of this misfortune. The two disciplines of economics and technology are linked. Economics is concerned with human behaviour arising from scarce resources in the context of multiplicity and growth of wants and economics looks to technology to solve this problem of scarcity since technology knows how to produce most with the least that is available. Economics presents her technical problems and technology solves them. Both have thus responded to the demands of man. Technology has over the last 175 years made rapid progress towards solving problems handed down by economics, but economics, is still confronted \\ith the problems of distribution if not of production. She has to solve the problem of poverty of one-third or one-half of the world and technology is expected to share the burden of this task. Technology has been a trustworthy friend of economics.

It was with the help of technology that economics has had revolutions in agriculture, industry, transport, commerce, finance, etc. But the sad aspect of this prosecution of technology is that pure science, the basis of technology has not been called into the dock. Possibly the reason is that it is the misuser of knowledge that is the criminal, not the originator of knowledge. Economics has had, like technology, its golden age in the 19th century, and since the thirties, a period of denunciation, from which it was saved only by Keynesian Modern Economics. This so called New Economics has tried to solve the problems of economic ups and downs over the time which were responsible for periodic economic distress. Then again, economics had a phase of sceptism or cynicism from which she was saved by the evolution of Growth Economics, Economics is now in the doc IC again for not solving the problems of the less-developed or developing countries. Meanwhile the 'growth' has come into disrepute and the alleged sins of technology which led to an anti-technology movement, are also laid at the doors of economics. It is said that 'growth' has involved environmental pollution, urban problems, widening disparities, etc, and an anti-economics movement has begun. Now let us stop our evaluation of economics here and look at the anti-technology movement.

ANTI-TECHNOLOGY MOVEMENT

This anti-technology movement may be said to have had its origin with the development of the hydrogen bomb which exposed the potentialities of technology for the good or bad of man. Then people began to speak about the sins of science, or, rather its application by technology, and engineering became the scapegoat. The writers against nuclear explosion were followed soon by writers who began to focus the world's attention on the huge pollution of the atmosphere from sources other than radio activity, such as the automobiles. Peoples' attention was drawn to the potential dangers to animal life from many of the wastes that were being deployed on sources of human sustenance like air and water. Treatises and novels came to be written to publicise and dramatise the possible I dangers. The engineer was pictured as the arch villain of the world's destruction. It was environmental crisis that tilted the balance against him. Till then the world was appreciative of his achievements and applauded him as the benefactor of mankind. The engineer himself began to lose his self-confidence and his smug satisfaction and social prestige were demolished in the span of a decade or so. The philosopher, the theologian and the anti-materialist cynic have joined hands with the humanists and romanticists to tarnish the face of technology.

It is suggested that had the engineer been socially and morally responsible, this environmental crisis could have been avoided and his prestige would have been unsullied, that if he had given a warning to the society and had refused to work on evil projects, the society would have been saved and he could have saved himself, from this present predicament. In the event, the critics have called for a new concept of professionalism on the part of the engineers, with an emphasis on social obligations. I think the suggestion of lack of moral courage is uncharitable to the profession. If there ever was a profession dedicated to morality, upright in conscience and conscious of social responsibility it has been the engineering profession. Its avowed aim as well as its chartered path has been to direct the great sources of power in nature for the use and benefits of man. This has been the ethics of engineering both in theory and practice. One shudders to think what the world would be like today had this not been so. The real fact is the engineer in the docks is a proxy of entrepreneurs who in search of profit had employed technology for purposes whose consequences on society were not or could not be foreseen, however, moral the engineer had been. The engineer's powers as against these entrepreneurs are limited, unless he is prepared to quit. Can we say that the employer could be swayed by the engineer's individual conscience alone? It is society's conscience expressed through the Government that must protect man from the nefarious entrepreneurs, though we have many instances the world over of individual engineers fighting against the dangerous practices of private institutions especially in the municipal field. It is a difficult alternative for an engineer to choose between the loyalty to his employer and loyalty to the society. Were engineers to prefer loyalty to the public above loyalty to the employer, is there a mechanism in society to protect him? Further, under what circumstances could we say allegiance to the public is called for and when not? For instance, the thought of the engineers designing and manufacturing weapons of war is horrifying to some of us but many engineers may consider such an activity as a patriotic function. The engineer may, like the economist, consider that he is there 'to do and die rather than to question why'. There are amongst engineers, as among any other class of people, persons of different persuasions; conservatives and radicals, idealists and pragmatists, hawks and doves. We can find amongst them conflicting beliefs and objectives, which govern their actions. It is not possible to restrict the practice of the engineer to those who have what we think to be the proper social and moral attitudes. If anyone were to define engineering morality by one's own philosophical predilections, we will only succeed in factionalising and politicising the engineering profession. The engineer has as much right, as any other to act according to his own right, unimpeded by any impositions from outside.

If we seek to impose on the engineer what accorcmg to us is the right thing to do in public interest, are we certain that our judgement of public interest is the only right one? Further, it is not always possible to foresee the consequences of our judgement and in some cases it is not possible even to agree on scientific and engineering facts or interpretations, ego the consequences of banning the DDT, artificial colouring of food, smoking, etc. Engineering experts may differ in their answers, and cases of such differences on technical issues are many. There is nothing unethical about such differences of opinion and Ne cannot impeach one as against the other.' Honest diffe ences of opinion will do good to the community at large.

Assuming that engineers can agree on certain interpretation of scientific facts, it is riot easy to say whether public interest will be served best by allowing the engineers to force their decision. It will be dangerous to give any organized group such powers over matters of public interest. Further, stressing the moral dimension of each engineering task might diminish the engineer's effectiveness and enthusiasm. Constant apprehension and anxiety about every move of his, might result in his lack of enthusiasm for innovation. We should not expect from him an assessment of social or environmental impact of each assignment. There are aspects of his work which others only are capable of analyzing and he expects others to be alert in this job while he himself is alert as to his aspect. Professional competence and protection of public interest do not go together. In a competitive world, where his employer is anxious to meet his rival's onslaught, an engineer refusing to co-operate on grounds of public interest will be sacked. The engineer is bound to consider product safety but cost of production increases with every increase in the degree of safety incorporated in the product and a trade-off is necessary, subject to the acceptability to the public of the risk in the use of the product. An engineer cannot be expected to assume a hard-line moral position which moves far ahead of public opinion or exceeds the requirements of the law. But in matters pertaining to product quality, the engineer's obligation is only to inform the employer and it is the employer who will be liable to the public and the law. He has been trained over the centuries to think mainly in terms of his efficiency and progress as interpreted by the market mechanism and he felt that he was discharging his professional duties in the most ethical way ifhe did the bidding of the market. We should not expect to find in the private sector the public spirited engineer of our definition. The public interest must be protected mainly by engineers hired by the public (consumer groups or public agencies). Possibly, professional societies like ours, should take more interest in fulfilling the engineer's moral obligation to the public, but with the well-known professional differences of opinion, their effectiveness cannot be great.

The current crisis in technology should call for a calm reflection rather than for dejection or penitence. The engineer cannot simply run away from his job. He just cannot, he is so much intertwined with the society. The legacy of the past and the call of the future chain him to his seat. Since technology cannot be abandoned on grounds of its past sins or future dangers, we have only to consider what can be done to avoid the repetition of technological mistakes which have brought him to this position. For this, we have to consider the types of mistakes technologists have made andthe reasons for them ..The technologists might have made mistakes by carelessness or error in calculation; for instance, mistakes made by the builder of a dam or a steel structure. Such a human error is a rare happening and is bound to decrease in the future with the advent of mechanical aids like the computer. Mistakes may result from lack of imagination; from a failure to take into account of all the possible sources of trouble. A designer of steel tower or dam may, for example, fail to make a correct assessment of the ravages of the wind and the weather, or of metal fatigue. Mistakes may arise from ignorance, pure and simple. Scientific ignorance of the consequences of an action is possible. Engineering practice is a constant struggle against these three kinds of mistakes and the engineer does not deny that he can be guilty of anyone or more of this and is prepared to be responsible for them. But in fixing of responsibility on him for things turning out to be different from what he expected, we have to be very careful. For instance, the engineer alone may not be responsible for the environmental crisis, pollutants have been emptied into the environment from a myriad of sources and the designer of each course does not know how many other sources were active or were being planned. Nobody can have a total picture of the net outcome of the aggregate of the individual activities present and future. Something other than engineering failure is at issue here. There has been a failure of environmental planning for the future, plans which take into account the aggregate effects of the individual actions. Such a planning is beyond the capacity and means of individual engineers. It is the society that must plan and pay for such activities. Individual engineers have in fact been aware of problems of pollution but they could not do 'much about it. One may say that they could have spoken out as professionalists and refuse to have anything to do with certain projects; but it would have like a judiciary declining to enforce certain laws because they thought the laws should be changed, Professionalists have an obligation to lead, but they also have a duty to obey and serve. Having been served as desired, society has no moral right to blame the profession for its own short-sightedness. In such matters as pollution, it does not require much technical knowledge to foresee dangers. How many letters to the editor do we not find in the. dailies warning us of the dangers of many public policies. Hence It IS a lame excuse for the society to say it has been misled by the experts, as if only the expert can smell the rat. Further, society is not only shortsighted; it also has a disconcerting way of unexpectedly changing its standards of taste, People want a particular public facility at a particular place and if, after its provision, find some inconveniences, condemns the engineer outright. It is irrational to blame engineers for things done at the behest of a society, which changes its tastes and standards rather frequently. We cannot expect from the engineers the omniscience which even the collective wisdom of the community does not have. They are as much perplexed as others about many outcomes of past , actions taken at the dictates of society, and they are not alone to be blamed as the scapegoats for society's omissions.

While on the one hand the environmental crisis was the first to put the technologists in the dock, there are others who got impleaded in the suit to frame up their own charges. They are not satisfied with saying that technologists have been irresponsible, foolish or immoral, but go further to decry the very role of technology itself. There has been a philosophical swing of the pendulum from unstinted praise for the achievements of science and technology until the hydrogen bomb burst, to an ungrateful condemnation of all that technology stands for. This anti-technology is not merely concerned with the environmental problem but with the entire life-style based on technology. Many writers especially in the United States have been crusaders against technology or technocracy. They are not against any particular technique and its effects or even about the use of machines, but they are against all deliberate and rational behaviour and efficiency in organization that formed the foundation and contribution of technology. They think that this contribution of technology lias damned mankind rather emancipated it, that it has destroyed the quality of life. This anti-technology movement is almost an anti-civilization movement. They personify technology as a monster, with a separate existence of its own, dominating society as an evil force. They allege that this evil force enslaves man and forces him to perform work which he detests. The target of attack is the time-bound, machine-aided, factory and office labour. The complaint is that all organized productive institutions are there only to make human beings more efficient tools of industry and commerce. Next, the technology devil is said not only to enforce production but also to drive men to consume things he did not care to. The consumer buys not what he fully needs or desires but what technology forces on him. Technology creates new wants and expanding body of consumers crave for their satisfaction through technology. Selfish technocrats are said to dominate the society with their expertise and supporting hierarchy and undermine democracy.

TECHNOLOGY AND DEMOCRACY

It is said that democracy is rapidly loosing its ground as the power is increasingly concentrated in giant corporations and managerial cadres, and that decisions involving the welfare of society are made by experts and professionals who are insulated from the feeling of the people. Technology is said to cut off man from nature, his natural habitat and dehumanise him in a soulkilling atmosphere. Finally, technology is said to debase human taste by providing technical diversions which dull his natural sensibilities and prevent his self-realization. Thus the charges against technology are that it is an evil force, a slave driver, supplier of unwanted things, a regimentor through technocrats, thwarter of human nature and fulfilment. All these in short seem to suggest that it is better than man goes back to the early stages of human civilization, where there would be no disciplined work, no scope for the play or fulfilment of desires, no organized production and no diversion. involving technology.

REBUITAL OF THE CHARGES

We have now before us the charge sheet from both the environmentalists and anti-technology sages. It is now time for us to meet their arguments and to create a positive case for the retention and growth of technology. Can we agree with them that technology is a necessary evil? One would not. It will not be true and it will be against our own conscience, knowing as we do what technology has done and can hope to do for mankind in the future. Most people will not say technology is an evil. The several charges levelled, by anti-technology sages are obviously false. But they have an appeal and a following and we have to examine why they have an appeal. The first element of anti-technology campaign is the description of technology as an evil force, left free and uncontrolled to tyrannise. Is technology an independent force apart from men? It is merely one aspect of human activity just like economic or political activity. It is a reflection of an aspect of human nature. It is an activity of choice, of relish and fulfilment of human urge to create. One philosopher has said, "Technology is not separate from man because man is by nature a technological animal. To be human is to be technological." True, but we cannot ignore the fact that people do separate man and technology, when as a result or technological activities there flow several consequencesphysical, intellectual, psychological and cultural-which appear to be independent of human will or direction. It is this potentiality of technology that gives handle to the anti-technologists. That these flow from technology, not from man, though he sets it in motion clouds the fact that technology is merely a servant of man, an instrument to fulfil his desire and that man must bear the consequences of his decision to get his desire fulfilled through technology. It is irrational to blame the instrument for the mistakes of the agent. Technology is what the society as a user wants it to be.

It is absurd to say that people work because machines make them work. The fact is all of us have mixed feelings towards work. We try to void it but we seem to need it for our emotional well being. Studies do not show that most people hate their normal work. The antitechnologist romanticises the work of the earlier times just to condemn the current technological age but with a httle imagination we can picture what hard work did our forefathers had to put in, on land, just to make a living.

It is a canard to say that technology forces people to 'consume things they do not want. If people indulge in, vulgar desires they are to blame. To cry against technology is to bark against the shadow, for how many people are there amongst engineers who have such a — dominating position as to control others as old slave .drivers and feudal exploiters of bygone days? In spite of the power and technological aids available, even governments are helpless against the law-breakers and criminals .and it is just not true that technology has increased the 'powers of any group in society as to deserve the blame .all to itself. That the people are hypnotized to consume what they do not need or want is a half-truth because the same technology is capable of enlightening the 'public and aiding the consumer movement. The common man's technical knowledge today is not so poor as alleged,

Lastly, comes the cry that technology is cutting man far from his natural habitat and affecting the quality of life he leads. But we may ask: who prevents a man from living closer to nature if he so desires? In fact, technology does not force people to live in flats if they choose to live in the countryside, nor does it appear to be true that living in the midst of nature is essential to human well-being. Is it true that all people would like to live their entire life in the woods? Why then the rush to the cities from the villages? A desire for occasional outdoor trip does not mean a lasting desire to live permanently outside the cities. Man has become a city dweller and likes the hum and bustle there, though he may long for .a change now and then. Are there not garden cities like this Bangalore that give him what he wants? As for technological diversion. if people desire one type of diversion in preference to another and the preferred diversion is technologically furnished, who is to blame? Not the technologists. The arguments of the anti-technologists are nothing but distortion of reality or mis-statements from prejudices.

A CONTINUING NOSTALGIA

While defending technology for its contribution and absolving it of the sins attributed to it, it is not maintained categorically that life in the technological age of today is better than it was ever before. From the beginning of the recorded history, we have had in every age prophets, poets and politicians who had deplored the contemporary situation as uniquely distressing and looked for some scapegoat to throw the blame on, and anti-technologists are the latest in this tradition. However, it is true we have problems .that are unique in degree if not in kind, which are manifested in a vague generalised discontent permeating even the best of informed minds. What is the reason? This is a complex question of sociology. The contemporary man is not content with what he has, because he wants more than he can ever have. Man is a unique combination of curiosity, creativity and daring. These traits have always been pushing him forward in search of new things or better things, daring inherent dangers. New technologies are only a part of man's elementary impulse to experiment, to create and venture into the unknown. The 'Contemporary restless man is only recapitulating his forebear. Possibly he will be happier if he had not had this urge to go up. This urge is not the work of technology but is inherent in human nature and technology is merely a manifestation of this urge. The spread of education and communication has widened his horizon and raised his expectations. Thus we see what it is that makes the modern man disgruntled and escapist. It is this unsatisfied desire that has been taken advantage of by anti-technologists to decry technology. They try to sell their vision of ideal society which wiIl provide serenity and spiritual peace. But the fact is man will not br his nature long remain contended with serenity. It is hIS nature to become restless and to seek some new adventure: If he flees the city to go into woods, he will not long remam there. The anti-technologists want a change in this human nature and their prescription is anti-technology.

If they hope to .succeed in their effort, technology will not stand III their way. But they will get disillusioned because they are not the only people who claim to know the answer to so-called ills of society. The mistake of the anti-technologists is that they want to reverse the gear all of a sudden. What the society wants today is more thinking and courage, but they play upon despair and suggest retreat. Which way will man go? It is anybody's guess! The anti-technology trend is related to the antimaterialistic trend that has a long history. Ever since the days of the Greek philosophers, there has been in the West an emphasis on the greatness of thinking rather than doing. Another source of anti-materialism has been the New Testament, which forbade interest in material gratifications. The effect of these two influences has been to convince that materialism is a defect in human nature. But there is ample material even in Greek literature to prove that the people were interested in material aspects of life. If we look at the evolution of man we see how in the process of natural selection, material civilization has also played a part. In our own country of sages, seers, philosophers and religious founders there has been no dearth of preaching and writing against materialism. But the fact that we have not had so much technology amidst us as in the West, has so far saved us from the onslaught of the anti-technologists.

THE CARICATURE OF ENGINEERS

We have so far been concerned with the charges against technology. But there have also been charges against the engineer too. Often he is caricatured as a dull person who is too practical, analytical and non-emotional and some studies seem to bear out the existence of such a general type. It is alleged that their interests are almost limited to mechanical matters and some outdoor activity and that their restricted interests show themselves in their indifference to human relations, to social sciences, to public affairs, to fine arts and even to aspects of physical science not related to their profession. Although he gets along well enough in society he would rather deal with things than with human beings.

Can we defend the engineer against these charges? How can we account for this description which seems to be true in a general way? Partly these characteristics may be the result of the profession's increasingly scientific orientation reflected in the engineering education an ever-increasing reliance on theoretical science which meant little time for the students or the practitioners to be interested in anything else. But we cannot blame entirely science because we do see scientists who are cultured and concerned with other things. A partial explanation may be. the heavy load of the theoretical and technical subjects in the curriculum though the recent trend is towards lightening it. But may not the problem be ascribable also to the sort of persons that come into the engineering profession? Most of them come from the middle or working class families and they take seriously to the profession. They come to this profession with deliberate choice and highly screened intellectual calibre, not expecting either great monetary reward or high social prestige, but prepared for dull and hard work. Possibly with their career at stake they get so much absor bed that in due time they find the profession itself sufficiently satisfying and interesting so that they would not be deflected by other attractions of life. They are pleased with the work which is acknowledged to be socially important, and sufficiently creative to give a sense of social importance. The engineers are gratified that their education helps them to understand the physical world and to manipulate it for the betterment of society. Thus both by education and by training as well as necessity they tend to be highly practical and unemotional. It is on this ground that there is now-a-days a demand for introducing more humanities in engineering education.

TECHNOLOGY AND HUMAN HAPPINESS

It is the part of this anti-technology to question whether technology has contributed anything to human happiness. Welfare is a difficult thing to quantify. It is one thing to catalogue the possessions and enjoyments in physical terms but another to estimate their impact on the human mind. Economists have been struggling with this problem of estimating the quantum of welfare which material wealth brings about. They are not sure if money value of possessions and consumption units is a dependable measure. They are content with merely comparing two states or levels of consumption, assuming that the state with more plentiful supply of material requisites of life is more contributory to the welfare than the other with less. It is on this basis that changes in the gross national product and the per capita income are taken as indices of progress or backwardness. But the unfortunate thing is that this emphasis on growth rate has now come under cloud because of the real cost of the growth in terms of environmental pollution, resource exhaustion, etc. Doubts ale now raised whether technological progress and resulting material progress do indicate greater welfare. Thus the anti-technological wave has partly affected economic thought also.

THE FUTURE

Now the question arises as to the directions in which technology should proceed in the future. It is not possible now to cry a halt to the pursuits or directions of technology, nor is it desirable. Whatever the diversity of the content and source of human happiness, no one can deny that material requisites contribute to human well-being. Technology has improved and can improve the supply of these material requisites. If these are granted it is the duty of technologists to extend the frontiers of technology so that the gaps in the sup oly of necessary material between nations are reduced if not abolished. The less-developed countries are anxious to catch up and they look to technology for the fulfilment of their desires. It is not the duty of the technologists to question the wisdom of this choice, but it is their duty to adapt themselves to fulfil their desire lest they should be open to charges of discrimination. Thus while in view of the recent misgivings about their past and future performances they have to reassess their position in relation to society and technological research they have also the task of universalising teir services.

The first requirement for the discharge of their future duties is that the technologists should be able to exert their influence over society's deliberations. Now the technologist is too tied to his job and too retiring tomake himself felt in the world which is run by politicians and entrepreneurs who are subtle and devious in their ways and who are quite willing to exploit the fears and ambitions of the average man. If engineers weremore assertive they would be able to influence social thinking and social choice which would then be based on an awareness of the technological implications. The technologist is quite skilled analysing the likely consequences of. alternative courses of action and his knowledge in analytical methods will sharpen his own appreciation of social references. This means that theengineer must widen the area of his cognitions beyond his own 'sphere of activity. It is in this context that wehave to consider the role of liberal education for engineers. But we must be clear about the extent to which humanities will help. We should not make the exaggerated claim that humanities will change the engineer's character or mental preoccupations. It is not true that the students of engineering are in any way worse in, emotional awareness than students of other disciplines, nor is it true that humanities will be the proper panacea for all the ills of the world, much less of such professional mental lopsidedness. Their main contribution to theeducated mind is to kindle the motions and to make: all aware of the complexities of the drama of human life. But the literature depicting this drama deals not only with the noble and the virtuous but also with the seemy side of the world. But exposure to such literature will perhaps make the engineer less innocent and sereneand more subtle and worldly wise, so that he can meet others on their own level, while at the same time imbuing. society with the play of his integrity and rationality.

While reorienting his outlook on the world, thetechnologist has to survive the present' credibility crisis only by the success with which he tackles the problems. which have already arisen and are likely to arise. He hasto prove that the society can still depend upon him as in the past to solve his problems, but the problems he has to find solutions for are numerous. There are numerous startling studies that predict quick damnation to the world due to population explosion, exhaustible resources, insufficient fuel supply and pollution of the environment, apart from problems of nuclear proliferation and of transfer of technology to the less-developed countries, He has to solve all these problems witbout creating new problems as in the past, by a proper total assessment of the effects of ail these solutions. Since he cannot finance such projects individually, nor can professional bodies do it, he must rouse public conscience and through it force government to set apart enough funds for suchglobal calculations. Of course, it is not to be expected that he will ensure against all risks of error because to err is human. Nor can he be expected to find solutions. immediately for all the problems. Such an impossible demand would only cripple his venturesomeness and enthusiasm for experiment and the society would be worse for that. Already nations have made important advances towards a solution of the environmental problems, but their impact may take some more years to be felt. We can be sure that all these problems will be solved soon enough.

The problem of resource exhaustion in the context of population explosion is a real one. The implications of such population growth and the consequential resource consumption are obvious in terms of food, water, energy, living space, transport, recreation, schooling, etc. Already we are feeling the effects of food crisis and an energy crisis. Though the former has to a large extent been solved, the tackling of energy crisis is not going "to be that easy. Even nuclear energy has its limits, because ultimately the fuel has to come from the bowels of the earth and we have already started thinking in-terms of solar ener gy. The Club of Rome shocked the 'world by publicising the 'Limits to Growth' and predicting disaster by 2100. Among its solutions to avoid such catastrophe are resource-recycling and pollution control. They have posed a challenge to the technologist but there is no reason to despair; the technologist has seen and solved many such crisis in the past. It is only a question of how far society is prepared to pay for the cost of finding and applying the solutions. One can confidently say that the engineer will not falter or fail because it is not in his nature to falter or rest while a problem faces him.

As for the problem of peace, I am afraid that much politics is involved in its solution over which the technologists have no control. The devil has been let loose and .it is only informed conscience of mankind that can chain the devil. True, technologist has a share of responsibility for the emergence of the devil along with the scientist and he is now to share the responsibility a1so. He has to educate the nations to enable him to redirect the application of nuclear science for peaceful purposes only.

The other problem to which technology is expected to contribute is that of bridging the gap between the developed and developing countries. The role of the technologists in this sphere is a challenging one. Transfer of technology to them is not a simple question of financing the transfer. The real problem is the transfer of technology from one climate or environment to another. Advanced technologies cannot be transferred in zeta because of the difference in the social and physical environment of the country of origin of technology and that of the country of adoption. On account of these differences, their use in a developing country will sometimes be uneconomic and technically retrogressive. The most obvious difference lies in the physical environment. The difference between the temperate climate of origin and the tropical climate of adoption is a quite obvious handicap to technology especially in the case of agricultural techniques. Similar difficulties arise in regard to animal husbandry, medicine and public health. As in the case of physical environment, differences in the social environment and economic context of technical operations may prevent direct transfer. Since scope for such direct transfers may be limited, we have first to recognize what can be transferred directly and what can be adapted, then adapt advanced technologies to the low proproductivity economy and possibly restructure the context of operations to provide a more nospitable environment for the advanced technology. Taking first the adaption, there are three different levels to be considered, At the simplest level, advanced technologies may be adapted on-the-spot by adjusting or modifying the machines or the process or techniques; along with this goes the need for the transfer of knowledge coupled by this machine or technique and this must also be adapted to the new environment.

Since the advanced technologies are based on knowledge of science, transfer of technology equires competent scientists and engineers who are also familiar with the circumstances and needs of the transferee country. At the third level, inasmuch as existing knowledge was born of a different set up and so many not suffice the transferee country set up, there may be need for producing new knowledge. This requires a problem-solving apparatus which must be mastered, adapted and applied. This means, science itself must be developmentoriented just as economics got oriented into a developmental economics.

We find some persons supporting intermediate technology while others oppose this as implying return to primitive technology. This is intertwined with the question of pattern of economy and nation votes for whatever the degree of adaptation. Whether or not it will be economical to use a particular technology will depend on the cost patterns of materials and of labour. Difference in the cost patterns will check the transfer. Particularly significant are cost differences which reflect the relative lack of skilled labour in low productivity economics. This may perhaps really call for some capital intensive techniques in a labour plenty society, because it is cheaper to adopt the capital intensive technique than to train the indigenous labour. Here is a dilemma which can be solved only by a political decision.

Advanced technology must be adapted also to prevailing forms of social and economic organizations or conversely forms of social and economic organizations might have to be changed to exploit the potential benefits of an advanced technology. For example, the use of processing and other computer-based techniques may be warranted only when large scale organization is involved. Therefore, the assimilation of such advance technology presumes the existence or desirability of large organizations. On the other hand, not only can advance technology be adopted to the new environments, the latter itself can also be adapted to facilitate the use of the former, as for instance by the provision of infrastructure required for the employment of the advanced technology.

CONCLUSION

From what has been said so far, it might be presumed inspite of the present crisis of confidence that technology and science promise a bright hope for man that critics point out that the substance of my argument has been industrial civilization, which has for two centuries given us not only material prosperity but also a sense of direction, now seem to be losing its justification for survival and that if we are to forge a good future, selfconfidence in our destiny is required. Technology and science are closely interwined with human civilization and there can be no parting of the ways, unless man migrates to a non-technology planet. But engineers must endeavour to regain public confidence by solving alJ the problems and soon enough.

Let us remember that we live in a world ever-renewing itself with new hopes and achievements. Let us keep alive the exploring spirit which is the hallmark of science engineering and technology. The pursuit of truth is I endless and Satyameva Jayathe.

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Towards Tomorrow with New Awakening on Science and Technology

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पितः

भगवत् कृपा या काचिन्मया लब्धा
सा भवतः एव आशीषा।
संघात बहुलेश्मिन जन्मनि
मनसी मे काचिद्वा प्राप्ता
साअपि भवत सबृति कल्पात्।
शिक्षा ज्ञानयोर्मे भवान इव आदि गुरुः
तथ एतोरिदं सभक्तिकं अर्घ्य
आद्य मया गुरुप्रसादेन
भवतः चरण कमलयोर्निवेद्यत्॥

o o o

Bhagwat Kripā yā kāchimmayā labdhā
Sā bhabata eba Āshishā
Sanghata bahuleshmin Yanmani
Manasi me yā kāchidba praptā
Sāpi Bhabata sabriti kalpāt.
Shikshā gnānayorme bhabāneba Ādi guru,
Tat etoridam sabhaktikam arghyam adya
Mayā Guru Prasadena,
Bhabān Charnkamaloyor nibedyata

(Father, through God's grace whatever litt1e I have been able to achieve in my life is only through your blessings.

In the many-facet struggle of this life, whatever little light I have seen is but a part of the Solar Radiation of which you are the Sun.

Of all my learnings and wisdom, you are the Prime Preceptor — the great Guru and hence Guruprasad, your humble son stands today to offer unto thy lotus feet these few thoughts in thy Memory)

INTRODUCTION

That was a million, perhaps two million, years ago, when man lived and loitered somewhere on this planet somewhere in the now famous and the well known Olduvai Gorge — the grand canyon of human evolution. Project your mind unto that dim distant past when that primitive primat an ape like creature, crouched in his cave and struck with the grief of his dead dear one, was left pondering over the question of life and death, of pain and pleasure, of the fate of his children and eventually of himself.

And in the process of such pondering over the phenomena around him and about himself, the ape — like creature was evolving into- man, — the thinking man, the man with reason the man with emotions, the man, the devil and the man the divine, man with his physics and metaphysics, man with his physical and his spiritual science, with his science and Technology.

SCIENCE AND TECHNOLOGY

Science is Systematic Knowledge based on Experiments and Experiences

Science, as you know, is systematic knowledge — knowledge not only theoretical and philosophical but knowledge based on-experiments and erperiences, involving many methods and materials, many techniques and tools.

Prehistoric Man Toiling with Primitive Tools and Technology

Man has teen toiling with tools of bones and stones, hides, hoofs and horns almost from prehistoric age. He had then his primitive tools and also his primitive technology — though not the technology of the kind that he defines today. What is Technology?

Technology is Basically Applied Science

Some area of science covers the so-called exact knowledge — predictable and reproducible with precision. Some area of technology similarly is exact knowledge, predictable and reproducible with precision. Some of the laws of science which are at the base of technology are universal and hold good equally well for all countries and nationalities. Technology from this point of view is a world — unifying force.

While some area of science is exact, quite some area is empirical, not prediclable with mathematical precision. Weather physics, for example, is a science. But no one yet can predict with precision the exact himidity, temperature or pressure of the atomosphere at some point of time in future. No one similarly can predict the exact silicon, sulphur or manganese content of the pig iron to be tapped from an iron blast furnace. Nevertheless weather physics is a discipline by itself. So is blust furnace technology a science and a discipline by itself.

Apart from the so-called exact and empirical areas, a vast area of science is unknown (and in fact, in finer details quite some significant area is unknownable). Nevertheless, in recent years, attempts have been made to utilize science, its tools and techniques (and in a few cases even to use its basic laws) to develop specific and new disciplines covering man's endeavour and enterprises in human society. Like science of social planning, science and technology of life (Bio-technology.) and others leading to techno-social, socio-cultural and even socio-ethical' aspects of Technology.

Science and Technology are inter-wover in the entire Fabric of Society to-day

You know already the manifold blessings Science has brought to the human society — better medicines, better housings, better and swifter means of communications and travel and host of other comforts. Science has put into Man's hands more production and leisure, better control of diseases and prolonged life. But science, on the other hand has put into man's hands the Atom Bomb and other weapons of destruction. This has raised serious questions in the minds of all. True it is Science in this 'atomic' age will put into man's hands enormous power, energy and speed. But can it be that this tremendous energy to move without the right-direction of motion will lead us all to disaster? Can it be that man, who has not much changed from what he was thousands of years ago in his mental and emotional set-up, will in the long run perish with the weapons of his own make? Will the products of human reason under the impulse of human emotion set up a grand explosion in which civilization will perish? If science produces health and wealth and also produces the means for death and destruction, should we not call a 'halt' to scientific research? Or if that be not possible, should we not divert science towards useful discoveries and constructive researches only?

Before attempting to answer such questions it is necessary to clarify a few simple yet fundamental issues:

A FEW FUNDAMENTAL ISSUES

It is necessary to clarify a few Fundamental issues, some of which are well known to a good Scientist but which often create doubt and confusion to the young learner and the common men.

Scientific Research by itself is not Destructive

Firstly scientific research yield results which are by themselves not in any way destructive. The nature of the application of that research depends on the object alive in mankind. Inventions, materials or machines, you will all agree, are not by themselves good or evil. The part that a machine shall play in the human drama depends not on the machine itself but on the user of that machine namely man himself. The tragedy is thus not due to science or scientific discoveries but due to the human weakness or inhuman motives and desires.

Science not Responsible for War

Secondly, although wars in this age of science are far more destructive than those in previous ages when men fought with clubs and arrows, science itself is not responsible for war, There have bean terrific warfare even before the age of science. The War of Crusade was waged in the name of Christ. But certainly Christ was not rsponsible for the crusade. Similarly war may be fought with scientific weapons but neither the weapons nor science are responsible for the war. The cause lies far deep-seated in the dark corners of the human heart.

Man has much Advanced in Maching But- Not in Mind

Thirdly, man has advanced so much with his machines but so little with his mind. His mental set up has remained almost the same as thousands of years ago . And today he is as barbarian wth atomic warfare or aerial bombing as he was in prehistoric ages with his clubs and arrows. The solution lies not in the postponement of scientific research but in the refinement of man's mind in the improvement of his degraded and unethical ways of life.

Science Not Restorable for Ethical Degradation

Fourthly science is not rosponsible for the present degradation in the ethical standard of human behaviour. It is often said that science has made man more naterialistic in outlook. The tremendous advances all along the sciantific front have made man more greedy running after more comforts. Science is a modern devil to which mankind has sold its soul in return for a handful of material benefits. This is certainly not right. It is true that science deals with the material world but scientific outlook cannot for that reason, be identified with the so-called materialistic outlook. Science is not merely an accumulation of facts or only a body of formulae and equations; within that body lies the heart and soul of science — the spirit of science which enables one to seek and attain truth and creates an attitude of mind which can resolutely employ certain methods to materialize that truth for the common benefit of mankind. Newton's reverence for truth and his unselfish devotion to seek that truth for the benefit of all mankind have values no less important that all the laws he discovered. The spirit with which scientific knowledge is sought and attained is indeed as important and as real as that knowledge itself. And if this spirit of science be distorted by unscientific men leading to death and destruction, it is neither science nor the scientist, but the purpose alive in the darker corner of the mind of taan, in the world Within man. The greatest problia facing man today and which may continue to haunt him tomorrow is no other species but his own, namely, man himself. Tomorrow it will not be so much of a problem related to science of matter or machine but the problem very much related to the science of man.

SCIENCE OF MAN

Through the efforts of many minds man has djireloped same of the fundamentals underlying the se ;.ence of matter and metal. Can man develop the ttindamentals of the science of man? Certainly yes: There has been in recent years tremendous advances in man's quest for knowledge of himself. And in that quest we find that:

(i) Man is not only a community of cells, fibres and fluids — not only a body dissocted by the anatomist but a balanced blend of atoms and aspirations — aspirations born out of an amazing community of atoms, attempting not merely to build a body but a mind and a spirit that dwells within it.

But what is spirit? This question again cannot be answered stisfactorily in human language as much as in physical science the question 'what is an electron' or even 'what is matter' cannot be answered satisfactorily in human language.

(ii) Nevertheless, the tangible matter and the intangible forces that dwells within it are both real. And so are the tangible body and the intangible spirit that dwells within it. There is nothing metaphysical about the existence of the conscious or spiritual part of man, as much as there is nothing metaphysical about the existence of the conscious or spiritual part of man, as much as there is nothing metaphysical with regard to the spiritual aspects of the laws of nature —To quote Einstein,

> "every one who is seriously involved in the pursuit of Science becomes convinced that a 'spirit' is manifest in the laws of the Universe"

As it is with the physics of the body, as it is with the mind — nay even with the spirit that permits it. There are unquestionable evidence, scientific evidences and demonstrations that apart from the physics-chemical basis of the human body, there is a physics-chemical basis of the hunian mind. And man is ambitious today to step into the field, the most fascinating and exciting field of the present age, namely a physics-chemical basis of the human spirit.

(iii) This body the physical body-- the physi cal aspect of man though transient, is real and is important. This is well known. But what is not so well-known is the fact that there is another aspect of man which, in the absence of a suitable word, we call 'spiritual' which is more fundamental and more important.

Because science deals with all laws of nature and man being a part of nature, may well learn lessons from the laws of nature.

MAN IS A PART OF NATURE – LESSONS OF NATURE

The first lesson – Pinciple of Least Action

Every entity in the universe — electron,atom, molecules mtter, metal, machine and man — all are impelled by the principle of least action.

When I learnt the lesson of the principle of action in my college days and again when I learnt from my great father about the principle of ‘Karma’ or the ‘Karma Yoga in Gita’, I was fascinated to discover a fundamental link between the two. For example, matter, the scientists say, is constrained to move under the principle of action. Man, the spiritualistws say, is constrained to move in the current of ‘Karma’. Matter has no free-will. This is well understood. But what is not so well understood is the fact the man has no ‘free-will’, either with emphasis on ‘Ege’ man ordinarily feels that he is ‘free’ to will and to think. But such a feeling can hardly have a scientific base today. A will that wills from within (apparently spontaneously) is conditioned by the constraints closely linked with the rest of the universe. As Albert Einstain said “All will is caused will”.

This scientific conviction helps man to free himself from the fetters of the error of ego, with no room for impatience for the attainment of success nor any fear of frustration to face failures.

With no freedom of action, no freedom of speech, no freedom of will also, man is impelled to move under the constraint of the principle of action and other laws of science under the constraint of cosmic forces completely beyond the control of man. When looked through the eye-piece of modern science, one gets convinced that man fundamentally is more or less a cog in the wheel of a cosmic prime mover.

Through the eye-piece of the physical science thus one get some glimpse into the value and the scientific value underlying the spiritual science of Bhagwat Gita namely ‘Twaya Harisikesha Hridisthitene Yakta Niyuktosmi Tatha Karomi’

The fundamental concept is that man, though a minimum member, is a significant and important member of the great Cosmic Wheel, the great Cosmic Law — the Principle of Action the Prime Mover of all forms of energy and forms of work.

We all say that work is worship and Gita, the book of spiritual science, helps to provide the scientific foundation about man’s inevitable involvement in some form of work. And work needs energy.

THE SECOND LESSON – ENERGY AND WORK

(a) The second lesson is that non-living matter or metal, as well as living organisms like man, al1 are involved in an everlasting engagement with energy.

You all know what energy is. Energy is the capacity to do work.

It is fact of science that non-living matter as well as the living organism — the Atom, the Ameeba and the Man — all, are involved in an everlasting engagement with energy in so many forms and functions, leading eventually to some form of work — thermal, mechanical, chemical, electrical, electro-chemioal, magnetic, electromagnetic and so on. The fact stands that at the base of all phenomena that take place outside as well as inside the human body, at the base of all our actions (eating, drinking, breathing, sleeping, thinking and even meditating and praying) work comes into the picture at every instant and at every state.

We write this symbolically by the simple relation

$$dU = TdS + PdV + Edq + \Sigma (\mu_i \, dN_i)$$

where dU = change in internal Energy
T, S = Temperature and Entropy
TdS = Thermal work

Semilarly

PdV = mechanical work
Edq = eletrical work
udN = Chemical work

Work in the world around man in industrial plants and projects, in the field and in the farm, produces products, varieties of products — bricks, and mortars, metals and machines and many more, produces food to feed the body — a body that toils with tools and that smelts and shapes steel with hammers and wheels. This is well-known and important. But what is not so well-known, but what nevertheless is more important, is that there is a world within man that can smelt and shape his mind and grind it down to new dimensions.

The work in the world around, within the shores of our land here and beyond the borders of the seas there, help build man's physical wealth.

Man equips his educational institutions and universities, the laboratorias and the libraties. He equips well his temple of learning. But what, if the world within is not equipped for an urge to learn. He equips his research laboratories — his temple science and meditation. But what, if there is no mood to meditate?

Man invests so much today for the world around but so little for the world Within. He furnishes his hearth and home, clean and well but what than.? What, if he does not furnish the world within and remains empty 'Inside'? Thus fundamentally the second lesson for man to learn is his inevitable involvement in some form of work.

The third lesson – Energy and Entropy

It is a fact of science and law of nature (and this is the third lesson) that whenever a system, no matter what that system is, does some work, its potential ability to do further work decrease. And this potential inability to do further work we call Entropy.

Entropy is usually associated with 'Disorderliness'. Is the universe then ruled with the law of disorderliness? To avoid such erabarrasing questions, I have often defind entropy as the potential inability to do work

WHAT IS ENTROPY

As indicated before the concept of entropy is closely associated with the core opt of disorderliness. Entropy is therefore sometimes defined (and for good reasons) as the quantum of disorderliness in a body. The law of entropy is therefore the law of disorderliness. And when the teacher says that the law of Entropy governs the Universe, the student questions – 'Is then the Universe governed by the law of Disorderliness'?

The answer to this rather embarrassing question is both Yes and No. It is 'Yes' if one puts eraphasis in the word 'law' and says the law of entropy governs the universe'. The answer is 'No' if one says 'Disorderliness governs the 'Universe'. To avoid such embarrassing concepts, the author as a teacher has preferred putting to his students that Just as energy is the capacity to do work entropy is the negation of that capacity. Energy of a system is the potential inability to do work.

From this rather negative definition, it is now well known that entropy has positive actions and effects virtually in all processes and in all types of transform actions and has many important implications in virtually all fields of human discipline.

ENERGY AND ENTROPY – INTRODUCTION TO A FEW FUNDAMENTAL CONCEPTS ON THE IMPORTANCE AND IMPLICATIONS OF ENTROPY

Entropy – the Universal

The law of entropy, which is one of the greatest discoveries of the human mind states that whenever a system does work (unless it is an ideal reversiole world), its entropy increases and its potentiality for further work decreases. This is true for all systems from the non-living world to all living organisms, including man and his society. As Albert Einstein said: 'The law of entropy in its fundamental universal applicability shall never be overthrown'.

All Activities Entrapped in Entropy

All activities in nature including those of man and his society need energy. This is well known. But what is not so well known and often ill-understood is the fact that along with energy, all activities are inextricably entangled and entrapped in 'Entropy'.

Entropy – the key to all progress in Health and Wealth

Energy is recognized to be the key to all industrial progress, to all human comforts and wealth. This is only apparently so. Energy is not the key; it is 'entropy' which is the key. Entropy is the queen, as it were, that takes the decision in all phenomena, in all transformations and processes in the universe. Energy is merely her Chief Accountat that keeps this ledger and does the book-keeping on energy balances.

Law of Entropy — Law of Freedom — but Freedom with Disciplines

The law of entropy has some imolications as the law of freedom. Law implies order, implies discipline, implies consraints and restraints of one kind of the other. Hence, law of entropy signifies law of freedom but freedom with inherent restraints; and that what. exactly nature imposes everywhere in the non-living world as well as in the world of living organism.

Energy does 'work' – Entropy draws 'work-Tax'

Work involves comparatively more orderly, motion of molecules (as in the 'to and fro' or 'the up and down' motion of a piston, for example). But one cannot have this comparatively greater order out of nothing. One has to pay for it in terms of 'Entropy-coin' which goes to Nature's treasury as 'work-Tax' or toll and is no longer available to man anymore. Energy in the thermodynamic capital and Entropy the thermodynamic tax — with considerable implications in man's share and nature's share of that capital.

Redundant 'work' (Energy) and Abundant 'Work-tax' (Entropy)

No matter what work or what process man gets involved into, this 'work-tax' or 'toll', has to be paid at every instant of time in all forms of work, — good bad, redundant and all. And as man gets more and more involved in so much of work and in so many forms of work, as he spins round in redundancies, he goes on cashing his capital, his reservoir or resources of matter and energy, in paying incessently and increasingly Nature's 'toll' or 'tax'. Thus Nature's treasury gets more enriched with 'Entropy-tax' and as a consequence man's energy-capital gets more impoverished in paying off that tax.

So Much of Tangible Gain in 'Goods' Through Energy but with So much More of Intangible Loss Through Entropy

Man today is trapped in the exponentially expanding three 'P's - 'Production', 'Pollution' and 'Population' — seldom reasizing that at the back of all his tangible products and productions with all the tangibie 'Tools and Toys of Technology' — he is inevitably and invariably getting trapped in a vast web of intangible entropy. And as men draws down some quantum of his resources of energy to meet not only his basic needs but so many other needs, which are redundant, he inevitably drains down all the more some further quantum of energy. And a large and a lion share of that energy he loses to pay off nature's share of 'entropy-tax' which is no more available to man.

Entropy the Managing Director in Nature's Workshop — the Governess of the Universe

It is well known that every event in nature is associated with energy in some form or other, be it the world of non-living matter or the living organism including man.

Every phenomenon in nature, each and every action and reaction, every effort by man and nature depends on energy.

Energy is the Governess or Mistress of the Universe. And behind her moves — as a kind of her 'shadow' — the entropy.

The true picture and the actual state of affair, however, is completely different. The 'entropy' is in fact the. Mistress or the Governess of the Universe. It is entropy that controls how much energy will be made available for different processes.

Not Energy but Entropy Crisis — the Way to Ride Out of this Crisis

The Entropy of a system be it a dynamic system of particles or a developing system of men can increase thus far only up to a critical point. Beyond the critical point, the entire system disappears, either slowly or with explosive violence.

All systems, be they communities of atoms or communities of men-, -begin with some 'potential' for activities. As activities continue to grow, the 'potential' continues to decay depending (among other factors) on the rate or speed of activities. And as a law of nature again the rate of decrease of the notential in general is greater than the rate of increase of activities. For example, if the speed of activities leads to an exponential growth of the three 'p's - production, population and pollution - there is an exponential demand for energy. With an exponential rise in energy, there is invariably and inevitably not only an exnonential but a 'super-exponential' rise in entropy. If energy speeds up at some rate, entropy rockets up at a much higher rate with the risk of the system or the society eventually disintegrating or even exploding.

Within the borders of this land and beyond the seas, one talks and hears of only energy crisis, Fundamentally, it is energy crisis but entropy crisis. The only way to ride out, of this crisis is minimizing the rate of decay of the thermodynamic potential of this planet, not by the 'stationary state' of growth rate but decreasing the growth rate by decreasing rate of population and the high standard of living.

Not Total Energetics but Total Entronics — Not Money — Economics but Entropa-Ecoromics

In spite of the energy crisis, the world today is based not on energy system but on economic system, in which the Rupee and not the Joule is the currency.

Money is still the basis on whieh mah today makes plans and policies, on which he judges values and predicates the present and the future. In fact, most of the criteria of activities of the world is still economics — or better still politico-economics. This should change now. Man must plan and forecast, with activities based on science in general and energy and entropy and ecology — not only the physical ecology of the biosphere in the world around man but the ecology in the 'World within Man' — the ethical ecology in rarticular, based on thermodynamical laws which are very much more reliable.

Total Entropies — the firm Foundation for the New Technology, the New Economy, the New Ecology, the New Sociology and the New Democracy

Many of the thermodynamic potentials of this planet are very much limited and must be used with care and caution more on techno-scientific rather than politico-economic basis. Faced with the dilemma of a double route, one must select the one with the least Entropies, not necessarily only least energetic in Joule (J) or the most Economic in Rupee.

A toy car may be apparently most economic — cheaper in money and even in energy but very much more costly in entropies causing thereby more national wastes.

Pennywise in economics may lead to (and often does) pound-foolish in entropy. Classical and conventional economics today is no guide to scientific judgements nor to sound technical developments for the future or even today in the present situation. Not the total energy concept but the total entropy concert, that man must weave now and develop further this concept in his higher institutions of learning and research and eventually project the concept speedily and effectively in all his national activities in general and in mitigating many of his ills today, including the energy crisis in particular.

Entropy Eve-piece

Not the total energetics alone but the total entropies will offer man a new eye-piece to probe deeper into details and help to awaken him to new thoughts, to new dimensions of developments and eventually help him to develop a new democracy in the right direction to the right destination.

ENERGY CRISIS IN THE 'WORLD AROUND' MAN - WHY? BECAUSE OF 'ENTROPY CRISIS' IN THE 'WORLD WITHIN' MAN

Energy crisis is virtually a world problem today. It is focussing the attention of many — many in the techno-scientific, socio-econonic and even political world. How to keep fuels flowing is becoming a world dilemma — particularly in the so-called developed and affluent societies. Half of every-thing transported in USA is fuel.

The two causes (fundamentally it is one cause as we shall see later) — the two principal causes for energy crisis are :

(a) high speed of exponential increase in the world population

$n_1 = n_0 \exp(k_1 t)$ (1)

where n_1, n_0 = number of people at some instants of time t_1 and t_0.

and k_1 = some constant, increasing with time t

(b) the high speed of exponential increase in the overall rate of per capita of energy consumption $\bar{E}$

$\bar{E} = \bar{E}_0 \exp(k_2 t)$ (2)

where $\bar{E}$ = average energy consumption per capita

or $\bar{E} = E/n = dE/dn$

and k_2 = some constant, increasing with time t.

These two high speed exponential factors conjoin together into a kind of hyper-speed super-exponential rate in the overall energy consunaption. Combining equations (1) and (2) one may show that

$\bar{E} = n_0 E_0 \exp(k_1 + k_2)t$ (3)

where both k_1 and k_2 increases with t.

For many reasons the initial wrold population growth has been imperceptibly slow. From a more or less steady level in the Neolithetic Agricultural period, the world population edged up perhaps to around, only 0.4×10^9 by the fall of Rome. A thousand years later, the population touched the first billion (10^9) in 1800 A D. In other words, the population touched the first billion in 1800 A D, covering the entire period, of nearly 2 million years that man has been living and loitering on this planet.

Then as industrial age ushered in and industrial production gathered momentum with near-exponential growth in the production of goods and services from farms and factories, the second billion came in 1900, the third billion in 1950 and the fourth is expected in 1980. In other words the period of increase of population by one billion decreased progressively from. 100, 50 and 30 years. We will have one more billion people, that is, as many people as the whole of this planet contained from pre-historic age up to 1800, during the next 15 years. And the turn of this century (2000 A D or so)may see this planet loaded with 6 billion people — all using more energy and more materials. All concentrating towards more 'Movements' more 'wastes' and more 'Effluents' leading to more of not, only 'Energy' consumption but what is worse still more of 'entropy-creation' namely $\frac{ds}{dt} = S$.

A high speed of increase of population is thus an important cause of energy crisis. But a more icaportant and in fact a more dangerous cause is the high speed of exponential increas of the per capita rate of energy consumption, namely, $\bar{E}$ in equation(2),

(b) Per capita rate of enrgy consumption $\bar{E}$

The per capita rate of energy consumption $\bar{E}$ in some countries is doubling in a period less than a decade (10 years). In the recent past the energy consumption in the european community has trebled within but two decades. The so called developed countries with nearly 25% of world population consumes more than 70% of world fuel, leaving less than 30% for more than 75% for the rest of world people. Man not too long ago consumed and in some regions of the world man even today (Nomad for example harding his sheep or a farmer tilling his soil) consumes par year a mere 30 to 60 kg of coal, a sack of coal which he could easily carry on his back.

Today a man in the developed countrieswould need 5000 to 6000 kg of coal per year. In other words nearly a lorry load of coal just for one man. And in the super-developed country, each man needs not just one but two such lorry loads or almost 12000 kg of coal per year.

It is the increased par capita consumption of energy $\bar{E}$ which is primarily responsible for the energy crisis. Man in an affluent society today has been dependent on a progressively increasing quantum of energy which is quite out of proportion to population increase. The US increase population, for example, during 1946-66 was around 43% but the energy consumption virtually doubled, that is increased by nearly 100%. By the turn of the century compared to 1970, the U S A may see an increase of population of nearly 25 to 30% (nearly 270 million peoole) but the energy consumption is estimated to shoot up to 400 to 500%.

The two principal causes for energy crisis, namely, the exponential increase in population and per capita energy consumption, as indicated before, are fairly well-known. But what is not known, far from being well-known is that the danger lies not only because of the explicit magnitude of the load of people and the progressingly increased rate of per capita energy consumption $\bar{E}$. But more so, bedause of the implicit and inevitable association of these factors with the progressingly increasing rate of entropy production S.

(c) Entropy and Error

Entropy, as indicated before, is associated with error with 'disorder' with 'dissipation' and 'degradation'. And a high entropy density in the 'world around' and also in the 'world within', man may eventually land into an error—laden' 'ego-stricken' degenerated society, plunged into a whirl-pool chaos and confusion with 'self-inflicted' and 'ego-inflated' strifes and strikes for so-called self-survival on the edge of a precipice, poised precariously for a 'drama' which may be nature's plan of paying man with his own coin, his own last act of plunging hand-long into the 'mirage' of so-called self-survival and self-gratification. But to get in fact quite something else may be 'self extension ' and 'self-elimination'.

Higher Speedof Increased per Cpita of Energy Consumption $\bar{E}$ Why?

Because of higher speed of activities and aspiration towards more 'Quantity of living' rather than 'Quality of life' — desire for more 'exuberance' rather than 'excellence'.

As man in some sections of the human society continues spinning round more of his demands for so-called needs — redundant needs of goods and services — needs which were not in his mind but inflicted artificially from outside by so-called industrial sales and services and shows, all kinds of methods and machines, metals and materials, cakes and cans, tools and toys make inroads — deep inroads in his life and living processes.

All kinds of activities today — techno-scientific, agro-industrial and socio-economic activities — are fundamentally bipolar with an apparent positive 'gain' at one pole an a negative 'loss' at the other pole, high economic (so-called economy) production in one pole and an equally high energy losses in the other.

The fundamental reason for this is the high speed of some fundamental changes in the mode and mood of the modern man particularly in the affluent society.

In other words, the 'mode' of living and behaving, the so-called 'life-style' in the world around man and the mood of life, the attitude of life man adopt within the atmosphere the harbors in the 'world within' him.

And this mode of living and behaving and the mood of thinking and aspiring depend very much on

(a) Man himself (his inheritance – the DNA, the zygot he comes from) namely, nature of his system and

(b) The nature of his environment – the nature of the treatment he receives from the environment – the nature of the fluxes of 'messages' that he receives, particularly through his 'eyes' and 'ears' from the world around and the nature of the 'image pattern' the 'aspiration' that he weaves in his world within out of these messages of 'sights' and 'sounds' from the world around.

In the world around, it is the mode or the way man lives, behaves and acts – For example,

(a) it is the way he produces processes and preserves his food and fertilizers (whether he uses less wasteful 'bio-energy' and renewable 'solar energy' or more wasteful mechanical, chemical and/or electrical energies and non-renewable fossil fuel energy).

(b) it is the way that he clothes himself (whether with natural fibers or cotton, wool or jute fibers or the highly wasteful synt het fibers).

(c) it is the way he moves (whether in compratively less wasteful steam locomotives or highly wasteful, trucks, buses and autos rolling on equally wasteful synthetic rubber tyres).

(d) it is the way he performs his routine daily duties and enjoyshis recreations (whether playing, swimming, bathing and other ways using lose wasteful machines or with more wasteful machinized gadgets, tools and toys).

(e) it is the way that he generates energy and power particularly the most convenient and the most versatile yet the most wasteful electrical power.

All these and many more add up to tell the tale of the heavy deficit in the dwindling reserve fund in the balance sheet of energy account.

<u>Machine useful but Wasteful — Gains Time and Money but Loses Energy</u>

Machine, it must be exphasized, is useful because of (a) its 'speed' and (b) its 'precision'. But machine is wasteful and often highly wasteful of energy because of the same reason that it is useful, namely, 'speed' and 'precision'? The greater the speed, the greater the degradation of 'energy' and of environement and the greater the rate of entropy-production leading to greater 'error' and the greater the probability of poorer qualities of products and performences.

Precision implies imposition of more constraints in many steps of details of 'forms' and 'functions'. Each of these steps and details need energy. Each of these constraints implies negation of entropy (more information) in the 'form' or function and hence creation of entropy in the environment of that 'form' or 'funation'.

Machine gains time and money but loses energy. The loss of energy is often cuunulative in most cases because of the law of entropy and alsodue to the series of irreversibilities associated virtually in all processes in nature.

<u>Bio-machines Slow but Less Wasteful</u>

In this connection, it is of interest to note that unlike man-made machines, nature's biological machines or bio-machines from the uni-cellular amoeba to the multi-cellular man — are slow and comparativy unproductive but is much less wasteful of energy. The efficiency of a living cell or a living molecule (the Deoxy-Nucleic — Acid or DNA) may be as high as 90% or more compared to the best of 30 to 40% of man-made machines, whose efficiencies, based on the law of entropy or the second law efficiency, in most cases are no better than 4 to 6%. Yet man in some sections of the present human society is virtually mad to day to get these man-made machine energy slaves and use them virtually everywhere as become enentually a slave of the medicine of his ownmaking.

‘Slaves’— Human Slaves’ then — ‘Energy-Slaves’ now

Modern man’s great grand father used ed somewhere and someday ‘human slaves’. Man later revolted against the concept of ‘slavery’ and ‘human slavery’ was gone. But man's lethargy to use his own limbs lingers on. And so man, particultrly the affluant man uses today ‘machines' — so many 'machine-maids' or 'Energy-slaves' labouring virtually everywhere to maintain his machanised 'mode' of living.

And to feed all these energy-slaves each affluent man today has to engage the equivalent of nearly 1000 human slaves.

Load of not 200 millions ‘but 200 billions’

An advanced country with say 200 million people each with 1000 slaves, is thus loaded with more than 200 billion people. And 200 billion people feeding on energy resource can create a crisis of that resource. And when fed on 'energy' the inevitable result is ' Energy-crisis'. This is a forewarning and a lesson for developing countries to learn so as not to over-step the multiplication of ' machines'.

ENTROPY AND SPEED – HIGH SPEED IMPLIES GREATER ENTROPY, LARGER QUANTITY BUT LOWER QUALITY ENTROPY AND ERROR EVOLUTION AND EXCELLENCE

Higher speed, no matter what that speed is speed of chemical reaction or speed of industrial production, is invariably associated with a higher speed of creation of entropy. Higher speed of production of so much of tangible goods is associated with a greater speed of production of so much more of intangible entropy. Intangible though entropy is, it eventually leads to tangible losses of resources.

Speed yields quantity but shields quality. Haste is necessary and is often vital. But undue Haste is undue Waste. Creation of Novelty or quality is negation of entropy and negation of speed. Creation of novelty or quality is thus inherently a slow process. Evolution in Nature has therefore been, of necessity, a slow process, for the evolution of not one but many, many varieties of novolties in many varieties of species with progressively increasing capacities of coordination and 'pattern-rccognitionl — from ‘mouse’ to monkey and eventually to man.

Negation of Entropy or 'Negentropy' is Information. Nagation of entropy or 'Negentropy' is thus associated with negation of Error. There is thus a close relationship between Error and Entropy. The more the error is in a system the more the disorder and dissipation and the more the entropy in that system.

A system or society entroppod in Entropy eventually gets entangled with a load of ‘Errors’ breeding more errors and leading to instability and eventually to a crisis, a potentially explosive situation . An 'error ' under constraint however can function as an unit of vector. Action has within it the seed to negate that 'Action' to minimise or even to erase that 'error'. An error as a vector then functions as a compass needle, a pathfinder of the destination, the state of stability the state of maximum freedom of maximum entropy (S) but minimum speed, 'minimum rate of entropy production.

ENERGY AND ENTROPY— MAN'S SHARE OF WORK (INCOME) AND NATURE’S SHARE OF WORK-TAX (INCOME-TAX)

Energy is capacity to do work. But the very process of doing that work, as indicated before, involves some negation of that capacity. The mechanism of work involves motions of particles in some-preferred direction, as it were, to be able to move a piston to and fro or to raise or to or a load up or down. In other words, the motion associated with the process of doing work is comparatively more orderly than the comparatively random motion of particles associated with heat. And one cannot have this comparatively greater order out of nothing. One has to pay for it in term of 'Entropy coin' which goes to Nature's treasury as 'work-tax' or 'toil' and is no longer available any more.

No matter what work or what process man gets involved into, this work tax or process toll has to be paid for at every step of a process and at every instant of time in all forms of work, good bad, redundant and all. And as man gets more and more involved in so much of pork in so many forms of work, as he spins round and round in redundancies, he goes on cashing his capital, his reservoir — reservoir of matter and energy — in paying incessently and increasingly Nature's toll and tax. Thus Nature's treasury gets more and more enriched with entropy tax or the term (-TS) in the defining relations A = (U-TS) or G = (H-TS) based on the law of Entropy. And as a consequence man's energy capital gets more and more improver rished in paying off that tax.

Man today is trapped as it were in expanding and expanding exponentially production, pollution and population, seldom realising that at the back of all the tangible products and production — the tangible ‘tools and toys of Technology’, he is inevitably and invariably getting trapped in a vast web of intangible entropy. And as man draws down some quantum of his resources of energy to meet not only his basic needs but also so clled so many other needs which are redundant, he inevitably drains down all the more, some further quantum af energy and a large and a lion share of that energy to pay off Nature's share of entropy — tax which is no more available to man. This the reader may well see if he 'ponders a little over the law of energy and the law of entropy, to got what are known as 'free-energy' functions in thermodynamics. These functions or potentials, we must emphasize, are fundamental relations in 'different forms under different sets of conditions.

Internal energy U is the most important thermodynamic potential or capital. But what man could possibly get released at constant T for the maximum theoretically available work is not U but (U-TS), we call function A, the 'free-internal energy' function, that is, A=(U-TS).

The word 'free' means 'Tax-free' that is, what remains after Nature realises her share of toll or Tax viz the term (-TS).

Thus Entropy has far--reaching implications everywhere and in every process in Nature from the non-living world to the living organism including man — his matter metal and machine — his food, family, friends and foes, his own self and his society.

ENTROPY A SCALAR WITH AN IMPLICIT FUNCTION OF SOMEKIND OF A VECTOR

Energy is scalar. Entropy explicity is also that way. But behind all scheme of events in Noture, Entropy is the steering wheel and functions implicitly at the background defining the direction as a kind of a vector.

It is well known that every event in Nature is associated with energy in some form or other, be it the world of non-living matter or the living organism including man.

Matter itself is a condensed phase, as it were, of energy. If there were no energy, there be no matter. And then there is no creation and' no life either.

Every phenomenon in nature each and every action and reaction, every effort by man and nature depends on energy.

Energy is, as it Were, the Governess or Mistress of the Universe and behind her, moves as a kind of her shadow the entropy.

The true picture and the actual state of affairs, however is completely different. The shadow the Entropy is in fact the Mistress or the Governess of the Universe. It is Entropy that controls how and how much the energy will be made available for different process in the form of the so-called free energy or the free enthalpy.

Matter and energy are the basic raw materials with which mannanufctures virtually every things he needs, a manufacturing plant, raw material alone do not help. Nor even a good method nor a good machine. Both man and machine are necessary. Machine to make and shape products and nen to tae take 'decision' behind the machine, to shape the policy behind all planning of process and products.

In nature's workshop similarly, energy is drawn as the fundamental raw material but it is entropy that takes the decision.

In the ultimate analysis, it is the entropy that gives direction to a process. Man is unable to convert heat completely into work (without some other effect) because Entropy will not permit this. The course of events are as they are, because Entropy desires that way. Nature's movements are restricted because of restrictions imposed by entropy.

As indicated before the law of entropy is the law of freedom. But freedom costs money, costs energy. Energy is the capacity to do work. And it is a fact of science that non-living matter as well as living organism the atom, the Amoeba and the Man, all, one and all, are involved in an everlasting engagement in so many 'forms and functions' leading eventually to some form of work — thermal work — mechanical work, electrical work, electro-chemical, electro-magnetic work and so on. Work comes into the picture at every instant and every stage of event or a process, in every, form of work — no matter what the work is — good, bad, useful or useless — Nature takes her share of energy, her toll, which goes to her treasury and no more available to man.

The internal energy U is the most important thermodynamic potential function of a system. It is, as it were, the thermodynamic capital of that system. Like internal energy U,' the Enthlpy H, the Helmholtz energy A and the Gibbs energy G, as the terms imply, is resident in the system as Energy — as thermodynamic potential — thermodynamic capital.

While Energy is the Thermodynamic Capital, entropy is the Queen of the capital.

ENERGY, THE THERMODYNAMIC CAPITAL – ENTROPY, THE QUEEN OF THAT CAPITAL

What is thermodynamic capital? It is some thermodynamic potential entity capable of getting involved in some form of work (thermal, mechanical, electrical and so on) some form of activities (motion, transportation, communication, production and so on). But all decisions and directives of such activities or iginate from the 'Prime Mover' — The Chief of the Cabinet as it were, the Queen, the Entropy.

With increased speed and complexity, as one finds everywhere including science and technology and economics, the thermodynamic capital to start with may be large, but the end result eventually remains small and indeed very small, because of the inevitable degration of energy due to higher speed of creation of entropy, on account of higher or greater speed of production and on account of higher complexities involved in the processes of that production, fundamentally because of the implications involved in 'Speed'.

SPEED – A PRIORITY AND A PROBLEM

Speed — A Priority and a Vital Priority

Speed of development is, for good reasons, an item of top priority for the developing countries. In fact speed of production of some of the basic needs of life is vital for their very survival. This is well known. But what is not so well-known is the fact that while speed is a priority, speed is also a problem.

Speed – a Problem

Speed is a problem because:

i) It is a law of nature that the greater the speed — no matter what that speed is — under a given set of conditions, in greater is the rate of Entropy creation at an exponential or even superexponential rate. And, with higher speed of Entropy production is linked up a chain of troubles. For example, the greater the speed of Entropy production, the greater is the speed of Energy degradation, sooner comes the impact of all kinds of 'crisis', e.g. greater the 'Errors' involved in the process, poorer the overall-Quality of performances and products, poorer the overall Economy — particularly the-national and even international Global Economy.

ii) It is a law of Nature again that the greater the speed under a given set of conditions and environments the greater is the speed of degradation of Energy, that is, the greater is the speed of energy consumption. This increase in energy consumption and concomitant waste in energy takes place not pro-rata or linerly but almost exponentially.

iii) One hears of all kinds of 'crises' — particularly 'energy crisis'. And this can be shown again as a result of the law of Nature that speed is at the root of all these crisis — including energy crisis,

iv) The greater the speed of a process (no matter what that process is) under a given set of conditions, the greater is the probability of 'Errors' in that process and also the products. Because, as a law of Nature again, the Entropy function is closely related to Error Function.

v) An 'Error-laden' product is a poor product — poor in 'Quality of its performances' and 'Quality of its life'. Poor also is its "Life-time" its Longevity.

vi) Poor in 'Quality', though cheap in money, is costly in calory. And in the long run wasteful of resources.

vii) All these factors and many more reflect cumulatively on the 'Economy', which may sag down superexponentially with inevitable impacts on 'inflation', 'Escalation' and so on.

Thus other conditions remaining the same, the greater up the speed, the lower the 'Quality' and lower also the 'Economy'.

Speed thus stands as a kind of contradiction between the other two vital arms of production viz 'Quality' and 'Economy' of production.

VITAL NECESSITY OF FORMING NUCLEI TO NEGOTIATE WITH CORE THINKERS IN CENTRES OF EXCELLENCE

Here comes the urgent necessity in doeloping countries, where speed is vital alongwith quality and economy, for the creation of a small but strong nucleus of Fundamental Thinkers, who could sense and see through a maze of materials the 'Core' the Essential and function as liaison between industrial scientists, technologists and engineers on the one hand, and great minds in the fields of fundamental sciences at Universities and higher Institutions of learning and research on the other and advise to steer the Industrial machineries with speed and yet negate the adverse effects of speed (as indicator before) leading not only to higher speed of production but also better quality and greater economy of that production.

Priority Linked with Speed — the Scalar—but more so with Destination – the Vector

Speed of Motion, speed of Production is vital. This is well understood. But what is not well understood is that speed is a scalar quantity – and so is Energy. To make it a Vector, one has to decide the Direction, and the

Destination. The plane, the pilot and the petrol may all be there. But it is all useless without the compass needle and the objective alive in the Pilot's mind. Not only priority in speed but also the objective of speeding the feeding of the Basic needs round Defence (D) Education (E) and Food (F) is vital (not Redundant needs, which are not basic but parasitic).

Speed of material production. Yes. But what material? How much? And for what? These questions need be satisfactorily solved before speed be accepted along with quality and Econoy and Efficiency based, not simple on Energy but more so on Entropy.

EFFICIENCY BASED NOT SIMPLY ON THE LAW OF ENERGY BUT ALSO LAW OF ENTROPY

It is important and very important indeed that the concept of efficiency of the thermodynamic capital be not based simply on the law of energy, the first law, but more so on the law of entropy, the second law, which eventually determines what quantum of work, what quantum of goods and services out of a given capital of energy can be obtained and at what cost of the 'Entropy Coin'.

In the entire workshop of the universe, entropy occupies the position of the Manaing Director — the queen of the universe as is were. It is from her ultimately that all kinds of orders regarding the manner and methods of the entire business orginate.

Policy is decided by entropy. Energy is left with the business details of 'Book-keeping and Accounting' with 'debit and credit' and drawing up the balance sheet according to the law of conservation of energy.

But no matter what the Book-keepingt says, no matter what the 'profit and loss' account shows, the dividend is decided by Entropy. Out of so much of energy capital or 'Reserve Fund' it is entropy that ultimately dictates how much would be available, how much possibly could be spared to man for his share of so-called 'free-internal-energy', (U-TS) free-enthalpy (H-TS) and so on.

Enthalpy function or the so-called heat-function H is (U+PV) or H = (U+ PV)

But what man could possibly get under a given set of condition viz constant T and P is not H but (H-TS) which, as indicated before, we call G, the Gibbs free energy function, that is G = H-TS.

And with the best of technology and therman effiency known to man today, his Engine of Industry' can yield out of (H-TS) a small and indeed a very small fraction of (H-TS). This is 'because the overall cumulative efficiency of a process, made of many sub-recesses is a multiplicative function like probability.

For example, for a process made up of only three sub-processes involving thermal, chemical and mechanical mode of transformations each with the 'efficiency of 35%, the overall efficiency is a mere 4.34%. This is due to the the law- of Entropy and dissipation of energy through a series of irreversiblities and concomitant payment of a series of additional 'tolls and taxes' and event super-taxes of entropy to Nature.

THE NEW APPROACH TO ENTROPY — THE TOTAL ENTROPICS

What is necessary now is to have a look and a hard and a deep look, a new look at enerey and entropy and steer the society to a path of production based on a new technology and a new economy, based not only on the concept of total Energetics but also total Entropics not the concept of efficiency based on the law of Energy but more so the efficiency based on the law of Entropy.

ENERGY, ENTROPY AND EFFICIENCY – THE NEW EFFICIENCY AND THE NEW ECONOMICS – THE TOTAL ENTROPICS – A NEW APPROACH

The efficiency of a system is generally defined as the ratio of what the system delivers to what it receives. What the system delivers, as a product or products or even hyproducts and wastes, may in general be quite different in nature from what it receives. A steel plant, for example, receives raw materials and delivers finished steel. To say its efficiency n_1 = steel/raw materials, would not carry much meaning unless both the different quantities in the numerator and the denominator are expressed in terms of the same unit. This unit, for good reasons, is the coin of the country – the rupee or the rubble, the dollar or the Deutch mark. And the efficiencies of almost all products and the processes today are evaluated in terms of money – national or international currency.

<u>Money-Economics misleading 'MONEY' Masks Creation of Entropy and Creation of Crisis</u>

It has become increasingly evident these days that economy based on money alone is neither satisfactory nor scientific. Because the concept of efficiency based on conventional 'money-economy' may only reflect a local economy of a particular process or a particular product, of a particular region or a particular plant, in complete disregard of the national economy affecting a country and its people. On the same context, a high national efficiency based on national economy of so-called high GNP and so on, may reflect only local phenomena of abundance or affluence, which completely disregards the colossal global degradation of energy and what is worse still, a colossal global degradation of energy and, what is worse still, a colossal creation of entropy – leading eventually to the potential danger of the creation of a crisis.

Economics and Entropics

Most of the world activities today are tied to Economics in terms of national or international coin of exchange — the money. There are, of course, good practical reasons for this.

However there are equally good reasons and good scientific reasons today that economic be based on the entropics which in its turn is based on the law of entropy the law of thermodynamics. We recapitulate very briefly a few fundamental concepts of efficiencies based on the law of energy and the law of entropy.

The first law of efficiency

In theraodynamics which deals with 'therm' (heat) an 'dynamics' (motion or work), tho efficiency of a system a heat engine, for example, according to the conventional concept of economy, would be the ratio of the work W (the dynamics) that is delivered by the engine to the therm or heat say Q, which is received by it

$n_1 = W/Q$ 18.1

For example suppose tht the heat received by the engine be Q_2 and the work delivered by the engine be W suppose also during the conversion of Q_2 into W, a part of the heat, namely Q_f, is lost due to dissipative forces or frictional losses and balance of the heat $(Q_2 – Q_f)$ is available for conversion into work W. Than according to the first law and the conventional concept of efficiency.

$n_1 = Q/Q_2 = (Q_2 – Q_f)Q_2 = 1 – (Q_f / Q_2)$ 18.1(a)

But the law of Entropy refuses man the ability to have such an efficiency based on the first law alone.

The Second Law of Efficiency – the Energetic and the Entropics

According to the law of entropy, the efficiency n_1 can never be attained even theoretically. Because while some quantity of work nay be completely converted into heat, the reverse is not true. Nature must have her share $(–Q_1)$ out of Q_2 and the blance $(Q_2 – Q_1)$ is released for man to be converted into work W. In other words, even if man could in the ideal case negate all the dissipative forms of friction, that is make $– Q_f = 0$ the maximum theoretical efficiency according to the second law

$n_2 = (Q_2 – Q_1) / Q_2 = (T_2 – T_1) / T_2 = 1 – (T_1 / T_2)$ 18.2

where Q_2 is the amount of heat delivered to the engine at the temperature T_2 and Q_1 is the heat rejected by the engine at a low teraperatute T_1.

Relation 18.2 expresses the theoretical rnaximum efficiency, provided man could make his 'Engine of Industry' reversible, that is, free from all frictional losses. But this is eventually not possible, because almost all processes in Nature are irreversible.

And if the speed and complexity of a process increase exponentially, entropy of that process increases super-exponentially. And the efficiency than decreases super-exponentially also.

Today in this age of Atom and Acceleration, in this age of space and Speed, Technology today is trapped in the Tentacles of Entropy, particularly because of the higher speeds and greater complexities, involved in virtually all the activities of man today.

Total Entropics

The concept of total Entropies (TE) encompasses not just one phenomenon, one process or one interest but all allied and inter-related phenomenon and this helps to project a more realistic picture of a process, the losses and often cumulative losses involved, in a process or a product and therefore helps to define more correctly the economy — the national or even international and global economy. Because of the interrelated phenomenons, the computation of total entropies,though apparently somewhat involved, is fundamentally simple and essentially consists of

(i) additive terms and

(ii) multiplicative factors viz

(a) additive terms consisting of summation of many losses due to dissipation forces viz $(–\Sigma Qf_i)$

(b) multiplicative factors viz multiplication of losses reflecting on the final efficiency viz

$n = \Pi n;$

Where Σ and Π signify summation and product respectively.

The scientific concept of total Entropies is based essentially on

(i) the concept-of macro-irreversibilities — both in the linear and the non-linear aspects and

(ii) micro-reversibility in which friction exists but the dissipitative effects of friction disappear.

The concept of total Entropies has quite, a few important implications.

Total Entropies — Its Importance and Implications

Electricity — Great Waster of Global Eossll Fuel Energy

Based on the generalization of the concept of total Entropies, the efficiency of electrical power generation from the combustion of coal, for example, is around 6% only aid not the unusually high, and misleading figure of 30%.

To avoid misunderstanding, it may be pointed out that

(i) at the starting point viz at the point of source, electricity has got great input energy flexibility and

(ii) at the end point viz at the point of end use, electricity is the cleanest, the most versatile (and sometimes the most efficient).

But from the overall scientific and technological point of view, it is not enough to consider the starting point and the end point only but all points. From the point of view of getting electricity by the conventional coal combustion processes, electrical energy is a great waster and a great polluter and hence a great scientific and national nuissanco, particularly when one looks at it a little deeper on the basis of total Entropies.

The New Economics

As already indicated, the criteria of most of world activities today is still Economics. It should be supplemented and if necessary, replaced by the complimentary concept of total Entropies (TE). In fact, the concept of total entropies can help to develop a new Economics — a scientific thermodynamics Economics. This is not just for academic reason but for reason of man's well being today and even for his survival tomorrow.

High Entropy Money-Economy degrades Thermodynamic Potential

If the classical concepts of Energetics and Economics today are applied to global problems of tomorrow, relegating Entropies at the back ground, the result tomorrow then shall inevitably be what the Law of Entropy would eventually lead nan and his society to viz a society degraded to a level of low 'thermodynamic potential' — a state of 'degradation' and 'degeneration'— a state of virtual disaster in social terms.

The Conventional Concepts on Efficiency Scientifically Incorrect and Misleading

The conventional concept of efficiency — the First Law Efficiency is woven round the Law of Energy (the first of law of Thermodynamics). On this, conventional basis, one may say that the efficiency of an electric water heater is 70 per cent and that of a common household oven is 50 per cent.

These figures based on the conventional concept of efficiency are not only incorrect but misleading. Because a comparison of these figures may lead (mislead) the common man or even the young engineer to the conclusion that

(a) the water heater is more efficient than the household oven and that

(b) a machine with efficiency of 100 per cent is the best

The law of Entropy says that both these conclusions are wrong. In fact the, maximum theoretical efficiency for a water heater is less than 100 per cent, while, that of a household oven is much greater than a water heater.

The so-called efficiencies of air conditioners and refregerators and heat pumps may be 200 per cent or more. In other words, if you give to your refrigerator 1 J of energy, it gives back 2 J of work, creating, as it were, the additional joule in some mysterious way. To avoid such misleading and enbarassing figures on efficiency, scientists have coined a new name viz Coefficient of Performance (COP) and not efficiency for such machines.

The conventional approach indicates that the efficiency of electric water heater is 70 per cent. The total Entropies (TE) indicates that is a more 2 per cent. The conventional efficiency for a gas water heater is 50 per cent, while the TE indicates it is 3%. COP of heat pump is 270% while TE indicates that is only 9 per cent. An air conditioner efficiency (COP) is indicate as 200 per cent. But its total Entropies or TE efficiency is only 5 per cent.

Nature's Law based on Law Total Entropies

Man is a part of Nature. Laws of Nature know no bounds, know no barriers — barriers of political or economic boundaries.This is well recognised. But what is not so well recognised or understood that quite a one significant area of the fundamentals of political, economic and social sciences can be laid on the foundation of a few basic and fundamental laws of Natural sciences.

Total Entropies and the New Politico-Economic Framework Tommorrow

It will be helpful to man if he considers and considers now to develop his politico-Economic framework on the foundations of the law of Entropy— a law which shall never be overthrown(to quote the great scientist Albert Einstine) — a universal law, which is applicable from the non-living world to the living organisam, including man and his society. This approach of basing Economics on Entropies may seem rather extraordinary and unconventional. Yes, But the present extraordinary and unconventional situation demands ah unconventional but a rigorous scientific approach to facing the new problems with new-parameters. And one such new parameter is based on the concpet of Total Entropies (TE), which can help to develop and define a new Efficiency, a more meaningful and scientific efficiency — the Second Law Efficiency based on the Law of Entropy.

The New Efficiency and Energy Economy Policy Tomorrow based on the concgpt of total Entropies (TE)

Entropy — Efficiency more Scientific

The new efficiency, the second law efficiency, based on the law of Entropy is more scientific because it helps to indicate and associate the correct concept of available work or Free Energy as a measure of energy efficiency in different areas National Energy Economy and particularly so, in evolving a more realistic National Energy Policy. Moreover, it helps to bring to the surface and expose more emphatically the gross wastefulness of a process or a product.

Typical Example — the Calorific Power

The calorific power is defined as the amount of heat liberated by a unit of cass of a fuel, under a certain set of standardised conditions. This definition of the calorific power or the energy content of a fuel is no index for its usefulness or wastefulness — rather it induces and attracts, a prospective user or buyer to prefer a high calorific power fuel, with the usually erroneous concept that a higher energy value of a fuel per unit of money is always more economical. Actually though, it may be usually more wasteful. Because instead of being actually useful as expected from the first law — the law of Energy, a greater part of its energy is more often rendered useless, according to the Second Law — the law of Entropy. Available work power of a fuel (under a given set of conditions) appear to be much better and more scientific term than the conventional term Calorific Power (CP).

This may appear paradoxical even to the young engineer or the designer. Because he may argue that

(i) heat at a high temperature on do more work that the same quantity of heat at a lower temperature and
(ii) a high temparature flame (obtained from a high CP fossil fuel) increases the rate of heat transfer and therefore the speed of a process and of production and hence more economical.

True it is that heat at a high temperature can do more work that an equal amount of heat at a lower temperature. And it is exactly for this reason that when a flame at a high temparature (greater than 2300K) obtained from fossil fuel combastial is put for producing work at a lower temperature (heating, steam raising and so on) that its potentiality for available work is largely wasted by the erection of more Entropy according to the Second Law. The paradox or the dielemna disappears when one undorstand and rememmbers the implications and the far reaching implications of the Second Law — the law of Entropy, particularly for irreversible processes, not only in their linear but also the non-linear aspects.

The Blast Furnace or the Open Hearth or the Big Blooming Mill Manufactures Rupee and Wastes Thermodynamic Gold

The Blast furnace process is only apparently economical, because of the conventional concept of economy based on Rupee. That was mare than 50 years ago. The author remembers still how at TISCO (Tata Iron & Steel Company) he was told by the then Superintendent of Iron Blast furnace "We do not manufacture pig iron in blast furnace, neither do we manufacture slag nor do we manufacture blast furnace gas. We manufacture Rupees in Blast Furnace". I was in my teens then. I laughed in delight. I am seventy now. I laugh again but not in delight but in disgust for man's misleading Money-Economy, in disgust with the unscientific concept in this scientific age, the concept of "COINS and COUPONS" defining the Human. Destiny. As for BF, so for BOH and Blooming Mill, the second law efficiency is low.

Money Economy makes so much Money But So Much More Entropy with the Prospect of the Peril of Entropy Crisis

Good Many centuries have gone since metal was minted into money. Man since then has coined many new concepts, discovered many new laws. The unbreakable Atom has been torn to pieces. Man has tapped energy from the world within the Atom. Man lands and loiters on the Moon and spins in space for days, weeks and months. Yet the "Money" concept and the Money-Econony continue to mould all man's methods and machines, his Tools and Technology. The money-coin continues to define his economy. The promisary hundred Rupee Note continues to attract his attention. The paper coupon continues to coin all concepts of his cost and even his culture.

Man has endured quite long this "COIN-CULTURD" — the classical COIN ECONOMY. This Rupee coin be better be supplemented, if not replaced, now by the more vital coin — the thermodynamic coin, the Joule J/K or better some unit in "BIONOMY" like kg/J and so on, particularly at this critical period of man's history, when he is faced with the pending prospect of a probable peril. Not so much the peril of the so-called Energy crisis. But more so the peril, may be even the "Death-dealing" peril of an Entropy crisis.

It is time that we do not talk in terms of "Money-Economy" alone but Entropy and Economy in Man and Society.

Entropy and Economy in Man and Society

Society is not just made up of Bone and Store, nor goods and gadgets nor metals and machines but Men. And men make meaning when they are able to communicate meaningful message (Negentropy). And Negative entropy is low entropy.

Unfortunately today there are all kinds of communications — high entropy redundant communications with currents and cross-currents of different forces from different sources — be they Techno-scientific or Politico-Economic sources. All one and all, but aiming at Economics. All, one and all, spinning round and round Economic and Economics — Science and Technology and Industry and even Politics — all Eyes focussed on Economic based on "Coins" and "Coupons" on Money Coins and paper Coupons — all enmeshed in a mass of Abstractions involving high Entropy Economics.

High Entropy Economics

All Economy today is a vast array of Abstractions — abstractions including National Income, Rate of Growth, Capital/Output Ratio — Capital Accumulation, Demand and Supply and so on.

Abstraction by itself is not wasteful. In fact, abstraction as such is itself low-Entropic by nature. But the cross currents of forces of many contradictory and redundant abstractions lead to dissipation of Energy and creation of high Entropy, achieving something apparently good but quite -often negating many uoro things which are vital — achieving, for oxample, high GNP and negating low level prices and thereby denying low level basic needs. And this is what the common man questions. "And what is the result of all these array of abstractions? High GNP?"

Yes, High GNP — but a high GNP tailored with tons of Tranquilisers. The result of all those array of abstractions and activities is high GNP at one pole and a high spiralling up of prices at the other pole.

If Economics — the so-called modern Economics — cannot get out of the trap of a vast Net of Abstnctions of its own making and make the common man free from the fetters of frustrations and starvation, leading to premature Decay and, what is worse still, a spiritual Death, it is time we reorient that Economy. In fact one sometimes feels to scrap that Economy — the Entropy Economy.

High Entropy Politice — Economic Trap

The entire Infrastructure of the Society associated with Ultra-activities, of man is trapped today in a Politico-Economic system, involving all kinds of Administrative machines, all kinds of Management, all kinds of Internal and External and National and International financing, all kinds of Consultancy, all kinds of Industrial and Techno-Economic Planning and Policies, with so many and so much of Techno-Scientific Man-power — with so much of 'Mental-Momentum' — all but enmeshed again in a mass of Abstraction and Politico-Economic Dogmas. And with all these what is the result? So much of Hopes and Aspirations — exponentially rising Expectations followed by exponentially falling Frustrations.

High Entropy Dipolar Politico-Economic System—Much Ado about Nothing

If this Politico-Economic system today cannot get out of the 'Trap' of its own making we better scrap that Trap with that System, the High Entropy Politico-Eonomic Dipolar System, with so much of GNP at one Pole and higher prices at the other Polo, with so much of emphasis on a Energy Bill at one Pole with the prospect of so much more of high Entropy Inflation at the other Pole, with so much of Auction of Gold at one Pole with so much greed for that Gold to so much more Inflation of that Gold with so much of natural human resources at one Pole, with so many and so much of Sciences — interdisciplinary sciences — at one Pole, with so many high power meetings, discussions and decisions at one Pole, yet with so much more "Maunds of Miseries" and "Tons of Tears" at the other Pole with so much of investments in Men, Money and Material at one Pole and so much more of Entropy with so little end results at the other Pole, mean eventually Nothing— "Much Ado about Nothing".

Man makes Metal to make Machines. But Machines and Mechanics do not and cannot Reveal Man. The Revealation lies in the "world within Man" in a State defined by scientific parameters — parameters that call for constraints and discilplines loading to low Entropy. Mechanics as such cannot reveal Man. Entropy under suitable Constraints can.

MECHANICS ALONG CANNOT REVEAL MAN – ENTROPY AND REVELATION

Mechanics Along Cannot Reveal Man

Nevertheless highly involved and complex system that he is — a unique-entity that he is on this planet, armed with a unique "built-in", sub-system, the Brain with an amazing, high capacity for so-called 'Identification-Reactions', man has the potential ability for Revelation within-within of course, the limits of his internal and environmental external constraints.

Non-living matter Reacts to the Action of its environment. The living organism not only Reacts but Responds because of its ability to sense information from its environment in the world around and also because of its capability to coordinate this information in the world Within — within the feed-back and feed-forward systems in the Neuronal Organisation of that wonderful built-in Apparatus which we call Brain.

Man, in whom nature has through the millenia built a near-miracle machinery, wants not only to Exist but to Live, because of his capacity not only to React and Respond but to Reveal. Reactions Responses and Revelations are born essential as a result of Interactions — 'feed-back' reactions within the system and 'feed-forward' from around the environment essential as results of contraints of fluxes of Entropics at different levels of Entropy (+ S) and Negation of that Entropy of Negentropy (-S).

Entropy and Revelation

It is through this in-built ability that man has the potentiality — the thermodynamic potentiality of Revealing himself in his World Within and can help others of his own species to do so.

The awakening to the implications of the law of entropy can reveal to man a new Ecology and a new Economy – the overall Low Entropic Ecology with Low-Entropic Economy (the LEE).

ENTROPY AND ECOLOGY — THE ECO-CRISIS

Elcology is the science of environment. There is the Eco-sphere — the Lithosphere (the land), the Hydrosphere (the ocean) and the Atmosphere) (the Air) which has eventually led to the Bio-sphere for weaving and evolving life in land, water and air. These are well known. But what is not so well known is that at the background of all these, evolutions, behind all those drama is the star actor, the law of entropy.

The Eye-piece of Entropy

Had man carefully looked into and listened to this unique law, he could have foreseen through the eye-piece of Entropy itself the "on coming" of this situation today that he calls Eco-crisis on the one hand and the Energy-crisis on the other hand. And also Economic crisis and what not. It is not Eco-crisis, not Energy-crisis, neither Economic crisis nor any other crisis. It is Entropy because of the law of Entropy, the one law that can help build a "Climate of Calm" or the one Law that can lead to a virtual Entropy & Storm to sweep over this one planet and pay man with his own coin — the coin of Entropy and make him feel the pulse of his own making with an abounding energy — the solar energy for example, but meaning eventually nothing — 'Much Ado about Nothing'.

A Gift of Abounding Energy (Solar Energy) is Something But If Trapped in Abounding Entropy It is Then Nothing. Much Ado About Nothing

Energy is supposed to be the key to all progress — industrial, technological, scientific, sociological and so on. Energy is certainly essential nay even vital. This is well known and well understood. But what is not so well known is the fact that it is not Energy, but entropy which is the key to all progress.

A gift of abounding and perennial source of energy well utilized can usher in a new age of more life and a bettor life. Science has and still can put into man's hand enormous power, energy and seed. But all these are scalar quantitiee and can load, man nowhere. In faat devoid of the correct direction and destination, a perennial source of enormous energy may mislead man towards a Dark Age.

If a pilot does not know whore to go, of what use is the plane or plenty of petrol to him.

If a society does not know where to go, of what use can be a perennial source of abounding energy?

To pilot a society with aboundance of energy, with super-abundance of entropy is like piloting a plane with a lot of petrol but without a Compass Needle.

To provide a society with plenty of energy for speed and notion may involve the society in utter wastages of energy in all kinds of random and reckless motions in all kinds of redundant activities. Abundance of energy in fact may be a 'trap' to super-abundance of entropy and what is worse still, may lead the society to decay, to all kinds of high-entropic activities in a high entropy a society tomorrow, with. high entropy policies, plans and performance with high entropy education economics and ecology, with concommitant high entropy-density in the world around man as well as in the world within him, leading a large section of the society eventually and may be inevitably to dinress to premature degeneration and decay and even to death.

A living cell grows and then undergoes decay and death. There are various theories of Aging which are known. But what not known is that life 'Ages', when it gets laden with high entropy density, leading to a high density of error. Error is not the cause but a consequence of entropy.

And what is true for a community of atoms in the non-living Metal or a living cell, is also true for a community of men in a society. Entropy is there for life. And entropy also there for decay and even for death.

This knowledge of Entropy of the Law of Entropy can help man with a New Awakening not only for Energy crisis but also for Entropy crisis – a new awakening to help man for his evolution on this planet in future, towards a new society with a new democracy, living a life – a human life –worth living.

ENTROPY AND MAN – AGING AND SURVIVING – A NEW APPROACH, THE TWO SCIENTIFIC CULTURE

Man consists of multi-billion atoms — an amazing community of atoms of metals and non-metals that not only Reacts like the non-living and Responds like all other life, but Reveals — reveals New Messages that no life can other than Man. And this amazing three-fold actions by the three R's — Reaction, Response and Revelation — unfold eventually a two fold culture — the Physics and the Spiritual — the Intellectual and the Intuition through the action of a still more amazing community of co-operative cells.

A living cell is a vast of population of Atoms, of billions of atoms, existing and living through a wide varieties of non-equilibrium states from moment to moment. Yet the Law of Entropy, the so-called law of disorder, weaves out a law of order, because a vast array of micro-variabls get eliminated, leading to the survival of only a few variables in the form of the thermal parameter or entropy S and the dynamical parameter involving Volume V and the electromagnetic moment (multiple moment), with an amazing coordinated inter-play of mass m, charge q, and entropy S. And this external and internal constrainsts – external constraints of fields and forces, abounding in the Universe, and also the 'internal' constraints of the 'micromany', many interacting and inter-linked atoms and molucures. These inter-linkages lead to very much less fluctuation of the 'macro-form' organs of the organism exhibiting properties of life and living processes.

As in a cell so in a society. With a vast array of population of individuals, each with their specific 'mood and mode' of behaviour patterns, the very fact that it is an array of non-equilibrium parts provides to the Society in the long run with new oppotunities of pattern and order — a new interplay of scalar mass and energy with vector momentum and field energy-momentum tensor with Entropy as a link between the scalars, vectors and tensors.

Entropy is classically a scalar quantity. Yet relativistically on a cosmological background, entropy has important implications as vectors and tensors.

Even in the world within matter and metal, Entropy plays the three-fold parts of a Scalar, a Vector and also a Tensor.

In fact, even in classical Thermodynamics, Entropy plays the vital role of a scalar and also a vector, implying and eventually indicatings the direction of a process. Entropy plays a vital role in the evolution of Life and the direction of many specific types of creation and negation of Entropy, involving virtually all types of work and all types of transformation, end also all types of friction and dissipations involved in those transformations and work.

Work involves comparatively more orderly motion, the 'to-and-fro' motion of a piston or the up-and-down motion of a pulley and so on, unlike heat or the thermal form of energy, which is comparatively a more disorderly form of energy in a system. Life is a specific type of a process of many specific types of orderly motions and work, as well as degradation of energy as 'therm'or heat.

And work – no matter what work that is — involves the concept of potential and potential gradients of forces. Work can be obtained man or machine or from any system, provided it has some form of potential or the ability to do work. This potential ability or capacity to do work may be looked upon as some kind of a spring wound within a watch. As the spring unwinds, the watch does specific types of work, generates entropy and shows time. Whenit has completely unwounded itself it stops. But so long as the spring exists, that is, so long it has the internal degree of freedom (as we call in science) to respond to external environments, the spring may be wound back by an external agency. And than the watch starts ticking life and time again.

But this winding and unwinding processes cannot go on for ever due to the law of entropy. The spring undergoes in-evitable transformations (corrosion, erosion and so on) leading towards decay and ageing and eventual Death which involves loss of internal degrees of freedom to respond to the external forms of work or energy of winding.

Nevertheless, the rate of ageing and decaying can definitely be minimized again with the help of Entropy. Entropy conventionally is indicative of Destruction of structures and Accleration of Agening and Decaying, which eventually lead to destruction of structures of all entities in the universe, non-living or the living. But under suitable constraints, the same Entropy can help to minimize acceleration, thereby prolonging the life of that entity. And Man as a part of nature is no exception. Ageing is inevitable because of the inevitability of the law of Entropy. Nevertheless aided with the same law, he may continue Ageing and yet surviving with the health and happiness for periods depending on the flux of "Constraints from Cosmic Environment" (Cosmic Messages).

ENTROPY – CREATION AND NEGATION OF PHYSICAL AN EMOTIONAL SUFFERINGS – HEALTH AND HAPPINESS – ACCELERATION AND ALSO DECLARATION OF DECAY AND DEATH

Work and all form of work — Mechanical, Thermal, Electrical and Chemical and even Electro-Magnetic work — are incessantly going on at different rates inside a cell, with fluxes of mass m charge q and entropy S from its environment. Loss of internal degrees of freedom at different rates imposes different rates of Ageing and Dying.

<u>Creation and Negation of Entropy for Health and Longivity</u>

As for the living healthy cell, so also for the sick cell or even the bacterial. And also the virus. All and one and all are involved in the dissipative work with creation of Entropy. In fact, Entropy plays a vital role in the health and longevity of a cell, of an organ and eventually of an organism like man.

These concepts are not just academic. Based on these and few other allied concepts, tied to the cosmic rhythm in general and solar rhythm in particular, as well as concepts based on creation and negation of Entropy, pathological conditions can in many cases be minimized and in some cases removed.

In fact, Entrophy is there for Life and also for Decay and Death. Entropy is there for Health and Disease. Entropy is there to create and also to negate both the physical and emotional sufferings of Man.

<u>Message of Entropy for creating and curing maladies based on Experiments and Experiences</u>

This meassage of health and happiness, this message of freedom from physical and emotional sufferings – this new message of abounding Joy with astonishingly low level of actively with low Entropy is not just an abstraction, is not just an academic concept.

Here stands a Man, before you, an humble scientist, who has done nearly 3000 experiements on his own body and eventually cured himself of maladies and chronic maladies which cannot be cured by any known Medical Sciences. And the surprising fact is that, given the necessary Time and Environment, I can create these maladies in my body and again get rid of these. Such indeed is the Power and Versatility of Entropy and Energy.

<u>Entropy & Cancer</u>

And I shall not be surprised if the Law of Entropy, aided with some associated concepts and with suitable experinents on the line that I have done on my own body, may help to mitigate many more physical and emotional sufferings of Man including even in its early stages the dreadful malignant malady – Cancer, particularly intestinal cancer, which I was in the recent past supposed to have been afflicted with, accompanied by several symptoms of its early stages.

Entropy under constraint can cure maladies. On the other hand entropy let loose can create maladies, including even Cancer – a malignant malady which proliferates here, there and everywhere in the body, triggering off a chain reaction in the entire Soma System of the organism, with a precipitous fall in its thermodynamic potential, leading eventually to the failure and cessation of vital functions.

In fact, in the non-living world of metals and in many chemical systems also an accclerated cessation of functions can occur due to what may be looked upon as 'Chain Reaction' in Entropy creation.

Controlled Entropy is Combustion – Uncontrolled Entropy is Explosion

Controlled Entropy creation, for example, is Combustion. Uncontrolled chain reaction in Entropy creation is explosion.

As in the non-living world, so in the world of living organisms, including Man and its Society, as the speed of activities increases exponentially, the speed of entropy creation increases super-exponentially, triggering off some kind, of chain reaction leading to all kinds of crises and worst still, the Entropy crisis — the Entropy Storm.

THE ENTROPY STORM – "PHYSICAL" SMOGS AND SMOKES IN THE WORLD AROUND AND "ETHICAL" SMOGS AND SMOKES IN THE WORLD WITHIN

Not only Physical but also Ethical Smogs and Smokes

It is a rare sea that is devoid of storms. Life is no exception, particularly Man's life today in this Age of Space and Speed. With all kinds of Sights and Sounds, with all kinds of songs, shows and cinemas, with all kinds of visions and televisions, with all kinds of smogs and smokes — not only the physical smogs and smokes (belched out of the exhausts of machines and fumes of furnaces) but also the 'Ethical' smogs and smokes from unethical environments here, there and everywhere all around, man vritually is trapped today in a Torna do — a sea of social tornado — or his own making, particularly a terrible and turbalant tornado of his World within. And having created this tornado in his world within, deep in the world within, man seeks-in vain for a sheltering harbour of more and more 'Production',— production of so-called goods and services to meet not only his basic needs, his life saving needs but many redundant and practic needs with progressive escalation of so-called higher and higher standards of living, the so-called higher and higher Gross National Product — the so-called GNP a high GNP s good. But of what good a high GNP is, if it be tailored with tons of Tranquilisers. And the higher the GNP, the longer is the tail and trail of tranquilisers.

And all this what a good,scientist could see through his scientific eye-piece, the "Entropy-Eye-piece". And this what a good scientist can see even today and awaken the world — the world conscience through the power of his pen for man's well being Today end even for his survival Tomorrow.

It is unfortunate that with so much of investment for the world Around man, virtually nothing has been done so far on the basis of science to emphasize the importance and the vital importance of initiating and sustaining research on 'Science' of Man' the 'science of the world within' man, a "World Within", wherein man gets his shelter and takes his solaces, where man actually lives and shall continue to live all his life.

High Entropy 'Sights' and 'Sounds'

Like unhealth food and drink, it is a fact of science that unhealthy signts and sounds and unethical smogs and smokes (as indicated before) tend to create chaos and confusion tend to create tough and rough weather-storms and turbulences in the world within man.

With a fast and near restless life that man lives and seeks to live today, his, sensory systems receive all kinds of messages from the world Around and transmit these to his brain his cortex, initiating thereby all kinds of "Pneumena" in the world within, a world woven round his Central Nervous System — the CNS. As a result of all these confusing and chaotic torrents of signals from the World. Around, man's World Within is thrown virtually into a turbulence of chaos and confusion and trapped into an "Entropy Storm", in a web of "Actions and Reactions". The brain is forced to react back. Different centres of activities in this Headquarters of Administration — the Brain — are forced to spew forth a mass of messages in his "World Within" — messages which tend to sweep his system — the somatic system — into a spiraling and spinning chain of activities with concomitant consumption of Energy and also creation of Entropy at an exponential may even super-expontial rates.

Tiny "Entropy Storm" in the World Within Accelerate many Tiny but Mighty Deaths

As the electrical signals surges through the neuronal organization of the "World Within", the resulting fields and forces $\bar{E}$ the electromagnetic particularly — pours out fluxes of Entropy associated with fluxes of 'Bosons' (Phonon, photons, magnons- and so on) and Fermions (electrons). As this wave of flux of Entropy crashes on any subsystem or organ, it creats "mini" but many turbulences, involving a series of local tiny "Entropy

Storms", which in their turns spew forth many many mini-currents and cross-currents of mass, charge and Entropy and thereby tear down the system slowly but surely into many many tiny but mighty deaths.

"Entropy Clam" – Decelaration of Decay

Man dies tiny deaths every moment of his existence. In face every entity in the Universe starts dying from the moment of its birth. And Man is no exception. This is inevitable and unavoidable because of the law of Entropy. But what is avoidable however is that the rate of dying these little deaths can be decelerated and the date of final death deferred and delayed (though not conquered).

THE ENTROPY STORM – THE WAY TO RIDE IT OUT

The storm, the Entropy storm is there in the horizon for a moe critical crisis. And the way – the only way – for man to ride it out is to prepare himself from now to maximize conservation and minimize wastes. An outline of policies based on scientific principles and practices are indicated below.

Some of these suggestions may appear quite unusual and unconventional. But to face unconventional times, unconventional steps are necessary.

Quite some amount of human efforts have been devoted to maximizing fuel efficiencies but the efforts so far in reusing and reducing wastes have not been commensurate. With small investments in this area, the end results can be large. And with a little strategy on principles and practices and with the modern tools of technology, the warson wastes can be won.

PRINCIPLES AND POLICIES

(a) The Information (I) and the Inspiration (I) or the I-I Linkage.

On the basis that acceleration of production of the basic necessities of life and retardation of production of population are the twin life-saving necessities for many nations, what is fundamentally necessary is 'Inspiration' or the mases towards nation building tasks by the Political Power on the one hand and Information to masses as to how to do the tasks by the Intellectual power on the other. Powered by political inspiration (I) and steered by Intellectural information (I), a huge mass of humanity can be set in motion – and motion with speed towards the desired destination. Get this I-I linkage and see what happens. The common man then performs the uncommon.

(b) DEF (Defence, Education and Food) – The three Basic Needs

Human needs are virtually insatiable, almost unlimited. But most of the resources to meet those needs are limited. Put priorities on basic needs woven round DFE. All other actvities may be, geared eventually towards these three top priorties. Cut down needs which are redundant arid parasitic. Total Entropics help to do that on a scientific basis.

Quick and correct Decision more helpful when based on T-S (Techno-Scientific) diagrams rather than P-E (Politico-Economic) Diagrams

In Science, the Temperature Entropy or the T-S diagram is the basic, from which follows other diagrams the Pressure volume (PV) or the Potential-Energy or Pressure-Energy (PE) diagrams. As in Science, so it must be in society with of course different connotations viz. Techno-Scientific for T-S and Politico-Economic for P-E. No matter the dilemma, do not waste time. Patience pays but not when 'the iron is hot'. Do not unduly waste time on decision and policy executions.

Wrong decisions may have risks, some reasonable risks but wasting time on decision and therefore 'delayed' action, while the iron is hot are likely to be wasteful in the long run and may even be suicidal, in the sense that the whole game, so well planned and played, may get lost. And the whole drame, so well drawn and done, may set concluded in chaos and confusion.

Man – the most important and vital Thermodynamic Capital – a product of heredity and environment (Treatment)

Man is the most important thermodynamic capital. Use and threat him with caution. Leaving aside Heredity, it is important to remember that what the child today shall turn to do tomorrow, depends on the treatment he gets from his environment.

The most fundamental treatment (leavin aside the chemistry of a system) is the well known 'Thermo-Mechanical' treatment of Material Sciences. Therm (the Heat) and Mechanics (the Hammer) – the Heat and the Hammer of the Ancients that forged the Damuseus Sword and the Asoka Pillar, that stands untarnished even today as a pillar of Pride for the Nation.

Heat (the Therm) and the Hammer (the Mechanics or dynamics) together yield the well known 'thermo-mechanical' treatment of the metallurgist or the thermodynamical treatment of this text, to yield the desired product – a quality product that eventually does its 'duties' and hits hard and well in time the target.

What is "Heat" and "hammer" for the Metal is "Sight" and "Sound" for Man.

Beware of "Sights" and "Sounds" Aim at both the Physical Health and Ethical Wealth of the Nation

Take care of the 'Sights' and 'Sounds' with caution against all redundant high entropy Audio-visual treatments.

Good food and water are essential for the physical health of the Nation. So are good 'Sights' and 'Sounds' essential for the ethical health of the Nation. Wrong sights and sounds are more damaging and more dangerous than wrong food and water, bad food and water damage the Body. But the resulting physical melady may be taken care of by medical sciences. Bad 'sights' and 'sounds', however, set the whole Neuronal Organizations of Man in chaos and confusion, with concomitant high entropy density in the world within man, leading eventually to psychosomatic maladies and pathological social conditions, which can hardly be taken care of by medical sciences. So beware of 'sights' and 'sounds' and 'audio-visual' treatments.

Quality Survives – put priority and emphasis on the Quality Rather than the Quantity

Technological Advancements are not the only models of advancements. Advancements on more volumes and varieties devoid of values, advancements on more 'Heights' devoid of 'Depth' or 'Dignity', advancements on mere colour and costume, advancements on paper petals of pictures devoid of all fragrances of flowers or advancements on mere 'Quantities of Living' bereft of the 'equality' of Life, are all high-Entropy advancements. In fact they may even be dangerous advancement towards early decay and even death.

It is well to remember that in the history of evolution, the dinosaur – 'the quantity' is gone. The little Lemer, the Ape and then the Man – the quality has survived.

Nature's laws, including the law of entropy, are inexorable. If Nature could eliminate the High Entropy Physical Dinosaur, she could eliminate the high entropy intellectual disnosaur, the man.

Techno-Ethical (Physico-spiritual) Culture

The world is on its march towards Inustrialization. Developing countries like India, have to do the same. In fact, not merely march, they have to run at the initial stages a high speed race for inudustrilization for thir survival. But while the world today wants industrialization to develop some kind of an 'Industrial Cultures', it is not unlikely that the world tomorrow, trapped in the 'Toys and Tentacles' of technology, may look forward to this land, to this ancient land to transform the so-called 'Appropriate Technology' the High Entropy Appropriate Technology or the HEAT to LIT, to lit the Light of Low-Entropy Techno-Ethical Culture Tomorrow and give a new meaning to 'Production and Planning', a new meaning to industry and industrialization.

Synthesis towards "Low Entropy"

Synthesis of the two sisters disciplines – the Physical and the Spiritual today for Survival Tomorrow

A synthesis of these two partners disciplines – the physical and the spiritual sciences – appars to the author, as a scientist, to be the most important intellectual issues for man's well being today and even for his survival tomorrow.

The hard way is Nature's way of Evolution to minimize total Entropies

One finds all through nature in her evolutionary processes, that a hard life is a good life — good life in th sense that it is a life of low entropy density — a life of law and a life of discipline.

Discipline implies constraints, constraints implies less freedom, subordinating the 'self' and the 'Ego', the one for the many. Subordinating the one, to live with many with low entropy, is the key to Nature's Eco-Balance.

Solution of Energy Crisis Depends on Planning of People, Planning of Men as much as, if not more than Planning of Money and Materials

And the fundamental concepts underlying this planning is to plan for education so that the people – our good people – may get 'Armed' from within, the inspiration (I) and Information (I) for Nation Building asks. Get this I-I Linkage and see what happens. The common man then performs the uncommon.

Slash Down Activities Contributing to Entropics

It is neither possible nor necessary to delve into details. As typical examples one may indicate :-

(i) Slash down energy requirements particularly electrical energy requirements on redundancies and divert all possible existing power to the basic needs of DEF and then plan for (electrical power with the minimum burning of coal) to feed other needs of the nation.

(ii) (a) slash down imports (not related to DEF) particularly imports of high entopy redundant informations.

(ii) (b) Import low entropy thermodynamic capital in the form of a different raw materials not available in the country and export lower entropy thermodynamic products (as highly finished goods and gadgets).

(ii) (c) Do not import immitation (which the young and the inexperienced are liable to get trapped into).

(ii) (d) Talents and intellect help to create low entropy. Do not export talents, and intellect as such. Export low ebntropy products designed and created by talents and intellect. Our talents are comparable to the very best outside India. Make them free from the fetters of redundant Politico-Econonic constraints.

<u>Caution in Acceleration-Speed a Priority and a Problem</u>

We need and need vitally anaccelerated rate of transfer of technology but with the clear objective that technology eventually is to make our people healthy and happy.

Technological acceleration has been so rapid today that, in process of speeding up the production of goods to meet-the growing needs of the people, it has caused wasteful depletion of natural resources and dangerous deterioration of natural environments (ecology) at a colossal rate. It has also caused serious obsolescence of' methods and materials, machines and even men. It is proper that along with the transfer of technology to produce more, we plan and plan for now to initiate some transfer of technology to combat problems of ecology, and obsolescenee. For this country technology-should not only be to produce more but to produce clean and to preserve more preserve the machines 'to prolong their productive lifes for reasons of economy to-day and also tomorrow.

Speed is no doubt vital for us today, almost for our very survival. But on the background of many basic scientific values underlying the meaning of life and living processes in our heritage and culture, it is necessary that we plan and plan from new for greater speed. But greater speed we take not merely to meet the needs of more quantity in life but also to feed the needs of mere quality of life leading to better stability and better economy.

Economy literally means ‘frugality’ or ‘thrift’, implying carefulness in investment and freedom from extravagance and waste. This conventional concept is true today in its fundamental core.

Nature is sometimes apparently wasteful but always inherently economical. In her ‘ecological’ cycles between organisms and their environments, there is partically no waste. Following the lessons from Nature, some of the modern industrial complexes are evolving on this basis – on the basis of usable products only – no by-products or waste products. Our technology transfer may well be planned on these lines.

<u>Economy Related to Ecology and Speed</u>

Recovery of all wastes is helpful both from the ‘economical’ and ‘ecological’ balance sheets. Developed countries are spending crores on ‘Ecology’ and thereby earning more crores of ‘Economy’. Economy thus gets related to Ecology. And that what is also in Nature.

In nature however we find speed to be usually associated with waste. In thermo-science this is always so. The greater the speed, the greater the waste by dissipation through greater rate of entropy production (ds/dt).

In high speed of production, one not only produces more marketable goods but produces more unmarketable entropy. This loss remains intangible an at the background for sometime.

But as the country speeds up exponentially in economic growth with progressively higher standards of living and greater rate of social entropy production, a stage comes when the system becomes unstable and disappears.

With increased speed, however, the frictional forces also progressively increases. And as friction in some form or other is universally present everywhere in Nature (mechanical, electrical, magnetic and thermal friction and even human frictions). Being proportional to the square of the speed, it may be easily shown that the exponential rate is followed by the near parabolic and finally a near linear growth.

This general trend is found in many phenomena in the non-living world and also in living organisms including man and his society. For a complex system involving the fluxes – of mess, charge, entropy and other quantities, the resultant overall phenomena may somewhat deviate due to the effects of shifting environments and due to the well-known ‘cross-linking’ phenomena in the non-living world and the so-called ‘complexity’ effects in the biological world. Nevertheless the overall trend remains the same.

Very much more complex as the human social organisation is, it is reasonable expect deviations in the growth pattern. But the general overall trend of the growth of a non-equilibrium but stable system is expected to approach that shown particularly for advanced countries. How far this is true will be evident from a typical plot of Research and Development per cent of GNP as function of time in USA which appears to show trends towards a 'Near-Equilibrium' (that is, 'Non-equilibrium but stable').

Due to extraordinary and almost unpredictable changes in the environments, external and/or internal, (periods or depression of war or otherwise) the pattern of growth may very widely. But these are extraordinary circumstances. Organisms with high speed of growth and therefore with less adaptable features got extinct due to the shifting environments of evolution. Democracy is a slow machine and therefore a safe machine. It is comparatively safe due to its many 'built in' inhibitatory mechanisms for balance of Power.

Technology Transfer

During technology-transfer undue haste and speed has in the past created and may again create unnecessary troubles and difficulties. During different stages of technology transfer construction and commissioning stages, undue pressure from different extraneous sources have severally affected details of transfer, affected lives of equipment and furnaces worth crores of rupees of foreign exchange. The entire lining of blast furnace and the entire roof of an open hearth furnaces have collapsed due to undue haste soon after starting operations (even in advanced countries). That of course should be execuse to accept that such so-called unavoidable phenomena should happen here also. Hence the necessity of freedom at all functional levels, if technology transfer is to yield the optimum (at least the average) results with the desired speed and economy.

Economy in international technology transfer at the initial states, is primarily associated with economy in the foreign exchange elements, priorities of necessities and then later the rate of creation of wealth and experience to generate more technology in the infra-structure. These are all functions primarily of human relations (management), training and creativity, stimulation and motivation of personnel associated with the transfer and some experiences in associated but essential fields like information, automation and evaluations, purchase and sales and so on and now even of environmental sciences (ecological considerations). Technological accelerations in recent years have been so fast that economists even in advanced countries often feel that all the intricate economic implications involved in a complex technology have not been fully plumbed.

National economy in the field of technology transfer, as in other fields, is the integration of the economics of many different elements. What is economical to a large industrial complex, even on an apparently scientific basis, may not be so on a national basis. The management of a steel complex is fully justified to ask for a technology transfer that would increase productivity and minimize the cost of production. But such a technology may not ultimately help national economy with regard to certain key and vital raw material situation (coking coal in India for example). Here of course, in the interest of national economy lies the necessity of constraints on the freedom. Transfer of technology should be related to economy on the basis of 'National priorities, rather than 'local performance' on the basis of primaries and 'Relevancies' rather than 'Redundancies' and Randomness).

REDUNDANCIES AND RANDOMPESS

Redundancies or unnecessary trivials tend to creep in almost all 'function' & 'forms' and in so many forms and need be minimised. This is well known but what is not so well knwon is the fact that in Nature 'Relevance' is almost implicitly associated with 'Redundance'. And so is speed. The greater these speed, the greater the redundancies. But Nature has her secret to use redundancies 'for purposeful activities — so-called' 'complexity effect', in bio-sciences for example.

In recent yeas such discipline 'bionics', 'bio-energetics', 'bio-technology' have opened up new frontiers – common frontiers with technology, for utilization of 'redundancies' and 'refuses' and for minimizing 'ecological' errors. Some transfer of technology on these lines would be useful.

For the sake of speed and ultimate economy it is necessary to realise that some elements of 'Redundencies' are unavoidable and shall always be there and may in fact be used up. But the trouble begins when too much and too many redundant elements are there to create confusion. Emphasis may then get shifted elsewhere and sometimes even to 'redundancy' itself, creating thereby more 'confusion' and sometimes even a crisis.

It is well known that music is specific sequences of sound. It is a sonic discipline, rid of redundant sounds. Without that discipline music degenerates to noise. And with too much of it, noise is a nuisance.

There has been in recent years too much of noise by too many people 'rith too little of science or technology in their cortices They even suggest solutions and thereby create more problems if they are in positions of power, particularly when they suggest solutions based on their opinions and not on facts and do so with an amazing air of conviction and certainly on matters which need sufficident periods of exposure to scientific and technological disciplines. Sufficient periods of exposure in the laboratories and on the shop floor beget what we call 'experience',which helps not only to increase speed but reduce redundancies and rardomness.

Experience on the one hand needs time, speed on the other hand abhors it. Speed with experience has less redundancies than that without it. We have a large body of young scientists but not too many with experience. Mere large number tend to create more redundancies. Speed also creates redundancies. We have to speed up with this large body of young scientists with no experience and be therefore prepared to accommodate and assimilate some element of redundancies.

Experience needs waiting. For the sake of speed we can hereby afford to wait. We have got to plan for speed and often speed without experience. This is a problem. The solution is extensive and intensive utilisation, of scientists with experience and help them and get help from them to get things done with speed and economy. The solution is extensive and intensive utilisation of centres of Learning and Research, Development and Design for generation and transfer of technology with less redundancies, randomness and risks.

Transfer of Technology — transfer of Entropy

Transfer of this or that technology is essential or may even be vital for a developing country. This is well known. But what is not so well known is that transfer of technology — no matter what that Technology is — is associated also with the transfer of entropy. And random transfer of technology may involve redundant creation of entropy leading to so much transfer of technology with so much more of entropy — more of disorder. Hence the need for caution and constraint to what has come to be known as Appropriate Technology.

Appropriate Technology - Low Entropy Technology

With a load of a near billion people by the turn of the century, what technology we adopt to get the desired level of production of the basic commodities for the nation.

We have hard of 'Rural Industries', 'Rural Techrology', 'Apprpriate Technology' and so on. Thase are well known and well emphasized.

But what do we mean by Appropriate Technology ?

One may say that Appropriete Technology is that technology which feeds the needs of the Nation with speed and economy. But economy based on what?

Economy based on money alone is only one aspect. Economy based on money cacco is neither satisfactory nor scientific. In fact money economics may be misleading. The question then arises. In this age of science, what scientific base, what scientific policy do we adopt to define and formulate the overall criterion for Appropriate Technology?

This question of Appropriate Technology - the question of a scientific criterion for Appropriate Technology - appropriate to all independent of the kind of coin or Economy prevalent in a country, kept on haunting the mind of the author for quite some time.

At least the idea welled up from 'Within' that

i) if the laws of m ure are universal and does not depend on this or that economy and

ii) if Man is a part of Nature,

man may well be guided by learning a few fundamental lessons from Nature.

And the most fundamental lesson to learn from Nature is 'Simplify and Simplify', 'Minimise and Minimise' the rate of creation of Entropy, by minimising redundant details an unwisely overgron establishment entrapped in Entropy.

In other words Appropriate Technology is Low Entropy Technology.

BASIC NEEDS ON A PRIORITY BASIS FOOD EDUCATION & DEFENCE

Our needs are many but on a priority basis these needs need be few viz., those concerned with Food and Education and in the world that we live today also Defence Food, Education and Defence (FED). The FED for this illfed country appears to be the vital priority. All other developments and need be geared to feed this FED. A country must be able to provide food (F) to its hungry millions, and also protect and defend (D) them. The priority of an organisation to survive is basically linked with F and D in fact the entire evolutionery — process has also been a proccess of 'Learning', a process, of 'Education' linked with F and D. Education thus is also vital. This is well realised. But what is not so well realised is the fact that Education with emphasis merely on quantity is only apparently useful and may not eventually be helpful to progress. On the contrary it, may even retard the progress. And if quality be relegated at the back ground, more more numbers may become a dead load, and may eventually be dangerous in creating a crisis — an unnecessary crisis and clash of cultures - the clash between the culture of abounding 'Redundancy and Randomness' and the culture of closer 'Control and Constraints', the culture of 'Exuberance' and the culture of 'Excellence', leading to the paradox of large investment on Education and research with comparatively small and results.

Education thus is not just for a massive literacy drive-for the sake of making masses literate tut to equip them for better reception, and transmission of informations (informations based on values and scientific and cultural values) to help build a democratic social structure that would accept and assimilate 'Discipline', not something as merely academic but as a 'law of life' and living, that would aspire not merely for higher standard of living but for a better standard of life — not merely for more Quantity but a better 'Quality of life' — a Quality that creates a culture consistent with constraints and restraints (that we find in Nature and Natural Sciences) generating forces of 'Control' against exponential growth — against exponential growth of population and a redundancies that eventually degenerate into decay and death by the sheer lead of degenerate numbers.

I have dilated so much on education, because international transfer of technology is vitally linked or the one hand with education (not merely Qantity but also Quality of education) and on the other hand with our basic needs. These needs again are vitally linked with the nature of education — its quantity and its quality. Education is vital because of this double link. A high quality of education at the advanced level helps to meet the basic needs for domestic transfer of technology and thereby minimises the number and the nature of the nees from international sources. Also high quality of education at the primary and secondary levels builds the foundation of a democrery that desires a quality of life, rid of redundancies and therefore redundant necessities — a democracy that do not desire the undersirables, the undesirable affluence of multichannel neocultural needs associated with multichannel wanton wasts of good earth's resources — a democracy that wants to live and not just to exist, that wants a high GNP to live a high quality of life but not a high GNP tailored with tons of trpnquiltsers, that wants to grow speedily and effectively towards a high intelectual life but refuses to run the frantic race to the end point as intellectual Dinossaurs.

This reorientation of education based on physical and spiritual sciences, particularly at the primary level and proceeding all through at all levels, needs both short and long time planning but the seeds need be sown and sown now so that this country may take the lead to demonstrate that on intergration of science and culture can usher in a climate of quantity tempered with Quality, a climate of Exuberance tempared with Excellence for man to live in plenty and peace.

We need plenty of materials to meet the basic needs of plenty of our people and need them now speedily and effectively and economically. An eye on NEGATION helps to do that.

Entropy in the 'Creation' and 'Negation'

Entropy ordinarily destroys structure. But under suitable constraints, entropy can crete structure as indicated by the great scientist Prof Prigogine. Entropy is there fox Health and Disease. Entropy is there to create and also to mitigate physical and emotional sufferings of man.

Entropy and 'Spiritual Life' – what is Spiritual Life?

From this message of health and hainess, the message of a mitigation of physical pain and emotional sufferings, based on a host of experiments and experiences, it has become increasingly evident that a scientific life lived on the 'basis of the law of entropy eventually tends to become a low-Entropy life. And a low

Entropy scientific life is akin to 'spiritual life'. A spiritual life is a low entropy life which lives and not jut exist with redundances.

A low Entropy Scientific Life, Akin to 'Spiritual Life', is a Scientific Necessity for Man's Well being Today and Even for his Survival Tomorrow.

A low entropy life and a low entropy society, as indicated before, is more liable to live a healthy and long life. It is understandable therefore to any good scientist, involved seriously in the pursuit of science, that a low entropy scientific life akin to spiritual life, is a scientific necessity in this age of science for man's well being today and even for his survival tomorrow.

Man a Part of Nature – Lessons from Nature

It is time that man realises that he is a part of Nature and may well learn lessons from Nature.

The first and the most important fundamental lesson to learn is that laws of Nature show that if stars and plaints, can behave peacefully on their paths in the vast depths of space in the cosmic world of million of years man certainly can behave peacefully on this tiny terrestrial world on his still -more tiny orbit in the transient small scan of his life of but a few centuries. And laws of Nature in general and the laws of entropy in particular can show how to achieve a peaceful coexistance not only with his own species but in ecological balance with all.

It is time that man realises that man could evolve because of the opportunities of an ecological balance that Nature offered to him in the Bio-sphere for low Entropy production. And after living and litering on this planet for two million years, man could hardly afford now with impunity to live a life of such exuberance and speed and concomitant high Entropy as to negate the very environment – the very Life-supporting system that created and nourished him.

Man may continue speeding up his high entropic activities thus far but no further. Because man must realize now that a system in a given set of environments can stand so much of entropy density and no further. Beyond that, the system disappears either slowly or with explosive violence.

Athother import ant lesson to learn is that Nature permitted the Macro to grow out of the Micro and continue growing in the physical plane thus far but no further. The High Entropic physical monster — the Dinosaur — lived and loitered for a while and then was eliminated.

She then turned the whole of her evolution to a completely new direction to create Novelties in the Intellectual plane — the little Lemor, the squirrel, the monkey and then eventually the man.

Law of entropy, of course continued but continued an altogether different directions From 'Entropic' activities in the Physical plane to entropic activities in the Intellectual Plane.

But while the Dinosaur's entropic activities were limited to the load of his body with little brain, and also like other animals – limited to the 'Endo-Soma' organs (organs built biologically within his body) man's entropic activities are not limited that way. In addition to 'Endo-Soma' organs man's Intellect has armed him with 'Exo-Soma' organs (organs or mechanics of his own making) which threaten to trigger off a chain reaction in high entropic activities.

Can tan affort to continue running with a bewildering speed the race that he has been and still running so far pressing hard on the Accelerator and consuming up the limited non-renewable resources of Nature's Gift of Thermodynamic capital of Matter and Energy of this Planet?

Energy from the Sun or from the sea, man shall be able to harness someday as source of power – a seemingly perennial source.

But what about of Matter?

Recycling may fetch relief but no solution. Similarly alternative resources from land and ocean or alternative substitutes in methods and materials leading to conservation, may fetch additional relief but certainly no solution.

It is clear that the current trend of exponential rate of growth cannot continue for long.

It is time that may wakes up to realize that Nature eliminated the high Entropic physical Dinosaur. And if man turns to be an Intellectual Dinosaur, feeding on the Nature's gift of all the thermodynamic capital of this planet in the form of the limited reserves of low entropic non-renewable resources, at an exponential rate to meet the needs, the many redundant and even parasitic needs of a high entropic life in an affluent society, with effluents of entropy at a super-exponential rate, Nature may then pay man well with his own coin – the coin of entropy in abundance and super-abundance. Not population crisis, not economic crisis, nor even energy crisis. Man today, it appears stands to get entrapped tomorrow in 'Entropy Crisis' of his own making.

The Law of Entropy and the Law of Negation

Another important lesson to learn is that the law of entropy is unique and universal in the sense that it is the only law which is a law of inequality, dealing with Non-equilibrium, non-homogeneity, non-irotropy (anisotropy), Non-linearity and Non-reversibility (irreversibility).

All this 'Non' or Negation eventually helped evolution to negate the 'old' and to weave the new, the new order and the new structure.

It is this principle of 'NON' or Nagation that constitute Nature's so-called Free energy, namely not simply the energy 'U' or 'H' but something negated from that energy, namely (U-TS) or (H-TS).

In fact, this free energy, the partially negated energy, as it were, that makes Nature's world a world of structures and just a drift or dance of atoms. It is again this 'free energy' that eventually makes this world a world of music and not a world of 'Noise'.

It is this non-equilibrium between the hot Sun and the cold earth that constitues the cosmic capital – the cosmic thermodynamical capital. And a small insignificant bit of that capital is trapped in a molecule (chlorophyll, for example) which eventually becomes a source of tiny thermodynamic capital, weaving again the principle of Non or Negation viz. Negation of Entropy, that is creation of structure, in the form of potential food and fodder, long before this planet had any bio-occupants.

It is this Non-equilibrium between the hot star and the cold sky that constitutes Nature's Heat Engine of the non-liviing matter in non-equilibrium.

Out of the non-living is woven the first seed of life — the living Heat Engine, Heat Engine of a new kind, which eventually evolves into Man, not only as a Noun and a verb but an Adjective and an Adverb doing new kinds of work — work of Discrimination work of Design and Dovelopment — work of Research Development and then Revelation.

And all this eventually in the 'Sun-Earth' complex, with Solar cooking encapsulated in the chlorophyll through photo synthesis, has been producing the Green earth — Mother Heat Engine.

Lessons from Cosmic Constraints – Negation of Entropy and Creation of Quality, Ethics and Excellence

Cosmic constraints of fields and forces impose eventually new kinds of constraints viz constraints of Entropy and Negentropy. Coupling Entity (like entropy) and Negation of that Entity (Negentropy) implies a field with its field particle. Non-homogeneous field implies a gradient in the form of gradient of potential. And gradient of potential is a force. Constraints of fields and forces in an environment imply lower entropy – Negation of entropy or information in that Environment.

And the information – laden environment is eventually responsible for the so-called selection, the 'Natural Selection' and 'Discrimination' that creates Novelty, produces New order, new structure.

Information being the negation of entropy implies potential ability to select. The so-called 'Natural Selection' selects that free Energy (Negated energy viz U-TS or H-TS) as food or fodder which feeds and fuels the selection and eventually helps to weave the New and raise the thermodynamic potential in the scale of evolution even out of apparent Redundancies.

Redundancies – Quantity and Quality of Information – Reduction of Redundancies

You would not like to go through 100 copies of the same book, because 90 books are redundant to you. But you need 100 copies of the same glucose molecule to feed and nourish and also raise thermodynamic - potential of your cells that make you.

According to the theory of Information (quite puzzling to the young learner) 100 copies of the same book contain 100 times more information than one book. But that merely accounts for the quantity of Informaton but not quality. What you are interested in is not merely quantity but, quality of Information. In fact learning or Education does not consist of merely transferring so much of Information in quantity but also (and the more so) the quality.

Low Entropy Education

A meaningful low-entropy Learning or Education doe s not lie in the transfer of so much of Informaton from the environment to the system that evolves or learns, but on the reduction of 'Redundancy'

Reduction of Redundancy (Entropy) towards Excellence

Reduction of Redundancy (Entropy) is vital in Education of human learning. Reduction of Redundancy or Entropy we identify in human learning as something of a low entropic 'Entity' we call 'Abstraction'.

We talk of 'Abstracts' of writings or research papers. Mathematical symbols and relations are but struggles of the human mind to condense a world of thought in 'Abstraction'. The entire branch of classical Electrodynamics is condensed in but four equations of Maxwell. The entire branch of Relativistic Mechanics is condensed in but two equations of Einstein. The entire branch of Thermo-statics is condensed in but two laws. To seek learning and excellence is to seek greater Abstraction.

And Abstraction is the symbol of Negation of Redundancy – Minimising of Entropy and maximizing conservation.

SOME FUNDAMENTAL CONCEPTS OP SCIENTIFIC PRACTICES FOR MAXIMISING CONSERVATIONS AND MINIMISING WASTES TODAY FOR SURVIVAL TOMORROW

It is not necessary to go into details. The following are just a few fundamentals which May be helpful. For example –

(a) Propagate information. Information is Negentropic and helps Yeretion of entropy. For this purpose develop Energy and Entropy Consultants, if necessary.

(b) Propagate to the people that the Hard way is the Nature's way. A hard life is a good life, a life of discipline and dedication, creative of structure and of low entropy. And when the crisis is on us, the choice before us is either the herd way of life or the easy -ay to decay or even death, the choice before us is the moderate low entropy way of a long life or the fast and exciting way of a high entrmpy life destined to premature Decay and Death.

(b 2) These are not just based on opinions - not my opinion or any body's opinion. These are based on the law or entropy.

(b 3) The future is unpredictable. Whet Nature shall do is unknown and even unknowable to man. Nevertheless man can foresee a little further towards the Horizon tomorrow with the scientific eye-piecethe Ertrflpy Eye-piece.

(c) Get more production of matter and energy and not production of people and pollution - remembering that the rate of production of basic necessities has to be high initially, followed not only by a zero growth rate but a lower growth rate with a good low entropy long and healthy life.

(d) For minimising energy

(i) divert all possible existing electrical resources to all basic national activitics woven round defence, education and food — the DEF.

(ii) Get as far as possible to the Solar Light Culture of planning national activits (say from 6 am to 6 pm) based on the low-entropy scientific Indian culture, rather than the unscientific high-entropy modern midnight culture.

(iii) Minimise moments of people and products. A large share of nations' energy today is wasted on redundant movements. Sometimes 33% more of energy is consumed for the movement of people and product. It is vital that this is minimised.

(iv) People in general are extremely careless (either through ignorance or complacency) in using energy. The pressure and an unusual and most unconventional pressure is on us. We just cannot survive wasting energy the way we have been doing so long. Help people change their social habits and outlook, through education, law or otherwise.

(e) Give R and D not only a rupee for Research but another rupee to exploit that research. Our higher institutions of learning and research have talents to steer the nation clear of the impending storms. Make them free to function speedily and effectively, with freedom from the fetters of rddundant Politico-economic pressures.

(e2) The universities and other higher institutions of learning research are temples of mediation. Help them to get rid of the 'Dust-Bins' that are preventing them to create a climate of calm — the low entropy climate — to develop the climate of a suitable 'Mood to mediate' and create new knowledge helpful to all men in general and this nation in particular.

A VITAL SIGNAL OF CAUTION FOR LAY TOMOROW

Place priority to transmit the signal and the vital signal of caution on the concept of an inevitable and inescapable necessity of accommodating a decreasing growth rate as an important member in the framework of Techno-scientific and politico-economic planning and policy tomorrow on the basis of the inevitable implications of the Law of Entropy. This is necessary and in fact vital, lest man may not get trapped soon and by surprise with the storm of an 'Entropy-crisis'.

Had man thought and taken 'Action' in advance, with a little more care and caution on the implications of entropy, the present eco-crisis would not have caught man so soon and in such a surprise as today. This must not be permitted to happen in the case of the more dangerous and devastating 'entropy-crisis' or the 'entropy-trap', from which man may not be able to escape with impunity and may get paid with his own coin and with a good taste of the 1aw of Entropy towards a premature degeneration, decay and a large scale eliminrc,tion, if not, extinction.

On the other hand, living a lower standard of living' but a better standard of life - a low-entropy life-would help nature, within the framework of her fundamental laws including of course her universal law of entropy, to permit the human species a longer lease of life to enjoy the fragrance of flowers, the songs of birds, the wormth of the winter sun or the sights of nature's varied scenarios, for many more years to come.

Not the Money-coin economy but the entropy-coin economy would then decide the destiny of man.

Though not a life of redundant plenty and so-called prosperity, though not a life of 'Quantity', it would more likely, be living a good life — a good life in the sense of a life of good quality — a low-entropy life — with a good possibility and the prospect of health and happiness for many many years tomorrow.

TOWARDS AN 'ALPHA-BETA-OMEGA' — ENTROPY CULTURE TOMORROW

What destiny or direction man shall have in future is uncreation. But it is certain that all what man is doing now with his high entropy economics, ecology and education, may appear to be good today but shall not stay that may tomorrow, if we merely adopt the alpha-iota culture — with the acceleration and the imitation. The 'eyes' and the ears, through 'sights' and 'sounds', through vision and television, are invariably tempted to get trapped into the colour and costume of higher levels of living in the world 'Imitations'. 'Imitation tends to ignite the fuel wastefully -pith redundant speed and abundant entropy, with escalations of 'Expectations' followed by fruitless Trustations'.

No doubt we must keep our 'eyes' and 'ears' open, we must keep our doors and windows open for the sun-shine of scientific culture to come in. But if foul smell and wind start blowing in and tend- to throw all ethics and entities to the entropy storm, we better shut our doors and windows and top importing imitation, for the so-called higher standard of living, with emphasis as more quantity of living and less on quality of life. A high standard and high level of living is a high entropy living, which can be lived thus for but no further. With an aspiration to go further tomorrow let us take to a scientific culture based on the law of nature — the 'Alpha-Beta-Omega' — the culture of nature, with the ‘Acceleration’ the ‘brake’ for retardation and the ‘wheel’, for direction and destination.

<u>The αβω culture – the scientific Culture based on the Law of Nature</u>

Man is a part of nature, Metal is the material that helps man to make the machine not to conqure but to learn from nature and from metal.

And the most Important and fundamental lesson to learn is the importance and implication of the law of energy and the law of entropy and their interactions.

Energy, the scalar provides man with the the power acceleration for α speed. And entropy the vector can help man to provide with ω, the wheel, the steering wheel for direction and destination and their statistical interactions, the quantum statistical interactions within the framework of the Rules of game, driving license as it were, which demand the use of β — Brake or the constraint for retardation.

We find all through nature both in the world of non-living matter as well as in the world of living organism. This ‘Alpha-Beta-Omega’ ‘αβω’ culture ‘Elevation’ and ‘Evolution’ on the one hand and negation of that culture towards 'Elimination’ or Extinction’ on the other.

Entropy in Greek means also ‘Evolution’. Entropy has helped to evolve life and we find entropy also helps to deal death to life. Entropy is life, and entropy is death too. With this new awakening on energy and entropy let us press alpha, the accelerator for greater speed of production, remembering however that along with production of so much of tangible goods, we produce also so much more of intangible entropy. With production of so much of marketable goods, we produce also so much more of unmarketable entropy. And entropy we can produce so much and no further. The ecosphere of this planet can endure so much of entropy density and no further.

In fact had man but heeded to the law of entropy as much as to the law of energy, the ‘Pollution’ crisis, that we here today, would not have caught man so soon with such a surprise.

Even today we hear, only of energy crisis and man's endeavour to seek and attain some abounding source of energy from the sun and the sea to overcome that crisis. A source of abundant energy from the sea or the sun is something but if trapped in super-abundant entropy, it is the nothing — Much Ado about Nothing as indicated before.

TOWARDS A NEW LOW-ENTROPY-POLITICO-ECONOMIC LIFE — THE ‘SARVODAYA’ LIFE — WORTH LIVING TOMORROW

The economic resources of all ‘matter and energy’, the summum-bonum of all resources that constitutes the thermodynamic capital of this planet, demand not only economic use of these resources but poses the problem of their distribution — distribution not only for many people but for many generations.

The so-called 'Market-economy' — the so-called ‘Demand-supply' economy, prevalent in the mind of many modern economists today is of no help for the solution of this problem tomorrow. In our economic plan today, we have neither the picture nor the pattern of the 'demand-supply' situation tomorrow, the furthest that one can look through the eye-piece of so-called ‘Futurology’ on the background of the ecology and econothy today, stops at the horizon at the end of this century. As one attempts to see beyond this horizon, the pattern of the picture-based on the demands of the future defies imagination. However the fundamental of Futurology, if one has to develop the science of Futurology, based on the invicible and inevitable law of entropy, is indicative of a signal to convince man not only to reduce his number but also to reduce the present redundant high level of living and to reduce it to such a level that the generation totuorrow may also be able to live at some lower level of the thermodynamic capital, so that they may continue to have the provision for the basic needs, not just for Existing but for 'Living' with - some semblance of comforts of life, a human life worth living — but how long? At least that 1ong (which may be multi-thousand if not a million years) which may provide Nature the time — the vital time she needs to help the human species to evolve from the high entropy physico-economic plane today to the low-entropy ethico-economic plane and then may be to a still lower entropy physico-spiritual plane.

Energy from the sun (if not from the sea) man shall be able to harness as the source of power – a seemingly perennial power tomorrow. If and when the solar energy becomes the only source of power, the fundamentals of so-called modern economy today shall disappear tomorrow. Nevertheless the dogma of economic dictatorship may still be there because of the high entropy 'SOMA' culture, a culture that spins mostly round and round the Body alone a culture that spins round and the pivot of more and more exciting and extravagent, high entropy life.

Ambition and aspiration to go high is good but thus far an no further.

If man wants to go further on his journey tomorrow, let us plan policies keeping an eye on the law of entropy, so that man as a somewhat less ambitious species may have eventful but less exciting low entropy life, so that the future generations of his own species on this one planet may continue basking on the warmth of the sunshine tomorrow.

Let us, in this country at least plan our policies, our politico-economic-Techo-scientific politics, awakening and a new awakening on energy and entropy, so that this awakening may help man towards a law-entropy Sarvodaya, towards a New Society with a New Democracy and a new economy, living a life — a human life worth living.

HIGH ENTROPY CULTURE – THE VERY NEGATION OF THE 'LAW OF NEGATION' AND LAW OF ENTROPY

<u>Introduction – a brief historical background</u>

The culture of many ancient lands, China, Egypt, Greek India and others have their, own specific historical backgrounds and their own specificities. Nevertheless they all had one common aspect viz human discipline, mostly based on experiments and experiences. Discipline implies some form of constraints and restraints and hence low entropy. Nevertheless many of these great cultures often got entrapped in high entropic activities, involving complexities and redundancies born essentially out of overriding and exaggerated "Emotions" and "Attachment", in the forms of uncontrolled "Passion" and "Possession".

Emotion, Passion or Possession are themselves not harmful. In fact, "Emotion" is as important as "Reason". The two are interwoven into a pattern of life that man ordinarily seeks to live with his mundane possoesion here and there, hardly realising that within that pattern , those two viz, the "Essence of Motion" and "Rigour of Reason", eventually blend into one that remains the only guide when Reason alone can go no further.

Man's brian, may it be known (as a fact of science), just does not work on pure reason. Scientific work of a high order often wells from within, from the world of emotion deep in the world within.

"In the temple of science as in the temple of God" says the great Scientist Albert Einstein "the most wornderful and fascinating thring one experiences is the Unknown – the Mysterious. It feeds the fundamental Emotion, which is at the root of science as well as religion".

— EINSTEIN

Bereft of the implications of science and religion, man gets entrapped in high entropy because of uncontrolled and unrefined Emotion, Passion and Possession.

The Greek Homer, for example glorified both "Passion" and "Possession" and thereby set the wheel of a Tradition that still rolls on. The culture of "Passion" and "Possession" still holds Man in the grip of a Culture – a high entropy culture – entrapped in Complexities and Redundancies.

<u>The Low-Entropy Culture, based on Negation or Nonviolence, Non-attachment, Non-Fear</u>

Man's mind today, as much as that of his tribal ancestor, is hedged about the shadow of Fear – and Fear of no other species but his own. And this fear or shadow, a mere projection of his own image, is growing greater with the glare of sciences. In the absence of strength from the world within, which great ancient masters of India had built on the granite foundation of 'Non', of 'Action' without 'Attachment', without 'Violence and had emphasized the importance of this mental climate of 'Non-attachment' and 'Non-Violence', a climate of Negation in the world within; the modern man is afflicted more and more with the feeling of possession — possessing this and possessing that, possessing more and more of Quantity of Life bereft or 'Quality' of living.

"Possession" or "passion" as such is not unscientific nor dangerous. What is dangerous is when these conjoin together to cross Nature's barrier of the high limits of critical entropy-density towards instability, towards "Pathology".

"Possession" and "Passion" can both be kept within limits of low entropic activities in a low-entropy, Nature's culture towards evolution of excellence. Entrapped in complexities of colour and costumes and redundant activities however, 'Passion' and Possession' may eventually land man into the hands of a dangerous crisis – the Entropy crisis.

In this age of science this is unscientific. Because it is the very negation of Natural's laws, particularly the law of Entropy, which is enshrined as the law of Negation. The law of Entropy is the only law which is a law of Inequality — the Negation of Equality. And hence the law of entropy tells a different tale and sings a edifferent symphony from that of high entropy culture — the culture of redundant Attetchment and Violence.

We have attempted very briefly elsewhere to indicate an outline of the physical basis of such metaphysical concepts as "Spirit", "Spiritual Science" and "Spiritual Life" in relation to Entropy.

The ancient masters in the field of spiritual sciences in India were of course not congnisant of the law of entropy. Neverteless, through ages of Experiments and experiences, they realised the importance and implications of a culture, which eventually tells the same tale and sings the same symphony as the law of entropy.

Woven into the Indian culture for example, is the concept of "Non-attachment" or Renunciation. Renunciation is not Negation of Possession or Negation of Activities but negation of Redundant Cotaplexities. Negation of complexities means Simplicity, means Tranquality – a climate of Calm – a climate of low entropy ecology towards a low entropy society — a society based on 'Non' viz Non-attachment, Non-violence, Non-fear.

LAW ENTROPIC-ECOLOGY AND THE LOW ENTROPIC ECONOMY THE NEW ECOLOGY AND THE NEW ECONOMY

Ecology is the Science of Environment, the science of the mutual relations between organisms and their environments. Man is one such organism among many in nature – linked in a web of crossconnections and complex relations. Though quite some significant area of these complex relationships are not yet clearly understood (far from being clearly defined), it has become increasingly evident these days that these cross linkages and complex relationship have evolved through the ages a wonderful chain of multi-cycle systems, so poised and belanced as to maximise the utilisation of energy and materials, and minimise waste (minimum rate of entropy creation), all balanced in closely linked 'feed back' (and even 'feed forward'?) systems and sub-systems between the organisms and their environments. Many of these systems and relation are apparentry antagonistic, one struggling to survive at the cost of other but eventually co-operative one the whole, helping nature to weave the first seed of life from the non-living — from the atom to the amoeba and eventually the man.

MAN – COMMUNITY OF ATOMS AND CONGREGATION OF THOUGHTS A COMPLEX SYSTEM OF THERMODYNAMIC AND ALSO NON-THERMODYNAMIC PARAMETERS – A SYSTEM LAVEN WITH INFORMATION AND ALSO THE LOAD OF EFFOR (ENTROPY AND INTROPY)

1) <u>Man - Community of Atoms and Congregation of thoughts</u>

Man consists trillions of cells and octillions of atoms. But man is not simply a community of cells, fibres and fluids — not only a body dissected by the anatomist but a balancd blend of atoms and aspirations - aspirations born out of an amazing community of atoms, attempting to build not only a body a mind that feels and thinks that sings and sobs, that meditates in all kinds of modes and moods system of thermodynamic and also non-thermodynamic parameters, a system laden with information and also lord of error due to Entropy and also Intropy. From a world of atom of a world of reason and emtion, we find in man a culmination evolutionary processes in nature, wrought through million of years of many environments — of energy, entropy and ecology.

The unparalled enlargement of the human brain some 100,000 years ago resulting in 'Homnsapiens' created new forces which brought into a creature — the Man. Man like other organisms, is a part of nature with the unique feature however that he can see his place in it. And now within the last century he has developed the unique feeture of controlling and changing his envirnment with a staggering speed and on a bewildering scale not known in the entire history of evolution.

ii) Man the Paradox - the creator and negator - high Entropy Intellectual Entity may be paid with his own coin

It is a great paradox that while man knows that he is a part of nature, he often behaves as though he is the master of it, not as one of the inhabitants of this planet but as its landlord. While he has the vision to see and feel his place as apart of nature, he has also the vision, an illusory vision, that he can control, command and eventually conquer nature, that he has the 'free will' of his own, that his will is free of the constraint of the cosmos, that he is the master of his own destiny. All these spring from little science. More science tends to negate such concepts. With Science in one hand and Technology in the other, with the power of mathematics in one hand and the speed and precision of instruments in the other, MPD man has, for the first time in his evolutinary history, the unique feature of imparting unusual impacts on his environment. But such impacts may inflict injury so deep into the eco-system as to trigger off a chair reaction, unleashing the upheaval of many forces and phases beyond his control. Nature may then pay him with his own coin – the coin of Entropy – the coin of Intellect that he has been encashing so excessively and extravagantly in recent of decay of resources, with concomitant superexponential rates of increase of entropy.

It was nature that brought into play the forces and rehases that initiated the unparalleled enlargement of man's brain, the 'Homosapiens' that initiated and eventually brought him into being. And it may well be that this unusually enlarged brain and intellect of man may initiate reactions in nature in the Summum-Bonum of her cosmic environment, unleashing forces that may eventually negate that very environment, the environment of life supporting system that created and nourished him towards a New Awakening that eventually led to material Revolution, evolution creating a New Age — the Age of 'Space and Speed', the Age of 'Atom and Acceleration', setting the wheel of a New culture rolling, the culture of Acceleration.

The culture of Acceleration and Chain – Reaction – the Paradox of the three perverted 'P's – Production, Pollution and Poverty

The Industrial revolution got ralling the wheel of the 'Culture of the Exponential' — the culture of Acceleration and the Chain-reaction creating the paradox of more production and more pollution, the dipolar Dichotomy, with more production and poverty at one pole and more pollution and poverty at the other.

Armed with science and technology, man learnt for the first time in his evolutionary history to sow the seed for a multi-fold chain reaction; towards an exponential rate of growth in almost all directions and dimensions in the world around him and in the world within him. And this led to a technological acceleration so rapid that the two perverted P's, the Production and the Pollution – Production of men and materials and the concommittant production of Pollution – pollution of the 'Biosphere' in the 'World Within' him, pollution not only of the ecosphere – the land, water and the air, but also pollution of Poverty and pollution of progress and prosperity, leading to the worst of all pollutants today viz. pollution of the 'World Within' man, which seem to be loading man today towards the edge of a precipice tomorrow, threatening his safety and may be even his survival. And all this because of the state of a dangerous inequilibrium brought about bye virtual disaster in 'Ecology' not only a disaster in the hysical Ecology in the World Around' man but, worse still, a. disaster in Ethical Ecology in the World Within him.

Crisis in physical Ecology and also Ethical Ecology

The speed and depth of interactions between his innovations and ingenuities on the one hand and the environments on the other seem to presage a prelude to a new epoch in human history. Whether such a prelude will lead man to a precipice or a platean is not Icnorm What is known however is the fact, that the acceleration in the recent past has been so staggering and the surcharge on affluence and the concomitant discharge of effluents have been so bewildering within the last quarter of a century) that the pollution of the 'ecosphere', the atmosphere (air), the hydrosphere (water) and the lithosphere (land), during the lost few decades have been more thanthat during the whole period of past human history. What this will eventually lead to is not certain. What is certain however is that man's speed and acceleration of growth in the twentieth century have been so sudden and so staggering that it has shot off every index of life and living process like a rocket reaching for the stratosphere. And this acceleration in numbers of men and materials, in production and pollution has set man in this age of Tools and Technology on a course which, if not altered and altered soon, would shift irreversibly and dangerously the ecosystem of his environments, on which eventually his survival depends. Today with hardly a third of humanity trapped in technology, the stresses and strains are alr ady too apparent in the ecosystem. Singnals of an impending and heavy storm are already there in the human horizon theatening and to put the two worlds of man, the World Around him (with the inheritated Biosphere and the created Technosphere) and the World within him (deep within the core of his cortex) out of balance and in deep conflict. And this conflict has created a crisis, not merely a physical crisis in the world Around but also and more so, an Ethical crisis - crisis of the spirit — in the World Within him, a crisis, more baffling and bewildering than any encountered by man in his whole evolutionary history) leading not only to dangerous depletion of non-renewable resources but dangerous devaluation of duties and obsolecence of machines and materials and even of men.

Obsolesence in men-erosion of the ecosithere of the world within man, causing erosion in intellectual accomplishments and erosion in intelloctunl excellence, with all kinds of high entropic chaos in eduoption for excellence, with all kinds of crises but fundamentally the 'Entropy Crisis', the Entropy storm due to not only physical smogs and smokes in the Ecology of the world around man but also Ethical smogs and smokes in the Ecology of the world within man.

TOWARDS TOMORROW WITH A NEW AWAKENING ON THE LAW OF ENTROPY — THE UNFALLING FRIEND TO MAN

The concept of entropy was born in physics more than a century ago, (Clausius 1865) and in its infancy, it got its nourishment also in physics. Latter under the care of Kelvin, Boltzmann, Gibbs Maxwell, Planck, Einstein, Boss, Fermi and many other great minds, entropy developed from boyhood to a mature person of international, nay universal, importance not only in all fields of science but in all kinds of business in Technology and in Industry, in all kinds of disciplines and interdisciplinary sciences — in Economics, in Ecology, in Psychology, in Sociology and even in Arts and Philosophy.

And now as a wise old post centurian great -grand father of science, with more than a hundred and odd years of experience in its scientific and professional life, entropy is armed today with an eye-piece of vision and wisdom to probe deep virtually in all fields of human endeavour, both in science and in art, both in physics and metaphysics, dealing even with intangible entities, completely conceptual in character in the framework of the human mind, the less profound consequences not only in the world of non living matter but also in the world of living organism, not only in the community of atoms but also in the community of men not only in all human affairs but in the affirs of all living organisms — in the world of mysteries of life, nay even in the world within all life that gives value and meaning to life itself.

The author has struggled in the previous pages to present to the patient reader a glimpse through the eye-piece of entropy into some fundamental areas of human thinking and disciplines with the hope that those pages will help to create a new awakening on the power and versatality of the law of entropy virtually in every process in Nature, from the world of non-living, matter to the world of living organism including Man and his society. And as in the past so in the future the law of Entropy can help man with a awakening, not only on energy crisis but also on Entropy crisis — new awakening to help man for his evolution on this planet in future towards a new society with a new democracy, living a life a low entropy human life — worth living. The law of entropy thus can be an friend to man to build a better world for all to live, if not a high exciting and high entropy short life but a low entropy good life and a fairly long life with peace and plenty, with heath and happiness for all his children to enjoy sometime more the warmth of the Sun and the fragrance of fruits and flowers on this planet.

TECHNOLOGY AND MAN — LESSONS FROM NATURE FOR THE FUTURE

Technology, in this age of science, is systematic applied knowledge based on experiments and experiences. It is always in a state of flux. So it is a kind of Technodynamics.

Technodynamics is an involved science because technology is created by man and is transferred by man to meet the needs of man — the many needs of a complex "politico-socio-economics" organization of his own making. Technology thus in a broader sense is a "techno-social" phenomenon, woven round man and his society.

Apart from its direct association with the physical and economic aspects to meet the physical needs and aspirations, flux of technology or technodynamics is associated with socio — cultural and even ethical science – the science of the world. Within man, woven round his Central Nervous System (the CNS) to meet man's other needs which, in the obsence of a suitable word, we call spiritual – spiritual needs and aspirations.

The object of science and technology for a developing country is to meet the basic needs of man. And for this to be effective to all, the basic need is Education to help man to get himself "Armed from within" with a high quality of Education.

Quality of education is as important and in fact more important than Quantity. Quality of life is an important as Quantity – a quantity that sometimes is evaluated as the Gross National Product – the GNP.

Technology can help to raise the GNP. And this country by all means and with all her resources must strive and strive hard to raise its GNP but not the conventional high-Entropic GNP.

It is necessary for us to be cautions and take steps and take steps from now, as a part of the overall planning of the nation for our future growth, that a rise in GNP is not tailored by tons of tranquilisers and redundant wastes to meet many of the redundant an parasite needs of man.

It is definitely possible to minimize this by reorienting the nature of education and to intensify a balanced and integrated growth on the basis of the laws of nature. And man is certainly a part of Nature. Though apparently Compex, Nature is fundamentally simple in her speificities and priorities.

Apart from the problems of speficicities and priorities – specificities with regard to sophistications, specifications, standardizations and so on and problems with regard to priorities on needs, on selectivity and flexibility of approach to technology, the most vital problem for the country today is 'Speed' and a high speed of that transfer towards a high speed of economic growth on the one hand and a high rate of retardation of population growth on the other.

Speed of technology is a top priority today for this country. But while speed helps to feed the urgency to meet the needs, it is itself a problem, beset with dangers of degeneracy, dissipation and decay, involving redundancies and randomness, errors, entropy and ecology.

Fortunatly, however speed in nature is associated with forces that tend to retard that speed — forces of friction, all kinds of frictions in science and all kinds of frictions in Society that tend to retard speed.

Recognising these dangers, man, the 'cortex' of man that creates technology is likely to initiate, within its built-in and wonderful 'Inhibitory' mechanisms in the cortex, processes leading to 'short-circuit-electrical' impulses and new impulses to find ways and means to inhibit impulsive growth — the problem of parasitic growth of numbers — number of men and materials, number of needs and necessities. And this the country may well take the lead by creating a centre of Negentropy — a Home of Excellence.

<u>Academy of the Science of Man – a Home of Excellence and Negentropy</u>

This country, with its great values and scientific values underflying her traditions and culture, underlying the experiments and experiences of many of her great ancient masters, can certainly take the lead to establish a small but small nucleus of research – research of 'Science of Man' the science of the world within man, in the form of say an "Academy of the Science of Man" (ASM), on the basis of AASETS*. ASM could well offer opportunities to may of our talents in the fundamentals of the frontiers of physical sciences to probe deep into the "World within Man", quite a significant area of which remains unchartered and quite a significant depth unfathomed, and threby take the lead in unfording new knowledge on life and living processes and helping to usher in, a new democracy – a democracy that accepts and assimilates "Discipline" as a way of life and living, a democracy that desires and develops not merely more quantity but also a better quality of life – a quality that creates a culture consistent with constraints and restraints (that one finds in natural sciences also), generating thereby forces of control against exponential growth — against exponontial growth of population and poverty — that tends to degenerate with decay and eventual death by the sheer load of degenerate numbers, by the sheer load of parasitic growth.

** AASETS is an all India Registered Associated for the Advancement of Scientific and Ethical Thinking and Services.*

This country could then take the lead through this "Academy of the Science of Man" to establish a home as it were, a centre of one of the world's most far-sighted undertakings.

While most of other advanced countries are still puzzling as to how to safeguard the quality of life in the face of the twin pressures of rising populations and rampant technology, this spiritual plan – the national and, should I say, the international rehabilitation plan on a spiritual plane, can undertake the task of solving the problem of projecting the nation's environmental future in detail, to determine what its priorities should be and how to achieve them.

In fact, its goal is ensure that the daily life of man in the near future will be as good as human ingenuity could make it , with the services and help of technological talents, particularly in view of the exponential growth of population — this country touching a near billion nark by the turn of the century.

This Academy of the Science of Man or spiritual planning concept has nothing to do with political or economic or metaphysical aspects. Its purpose is science – the Summum Bonum of Science – the physical science and also the spiritual sciences – to present approximate outlines of likely developments which could be used as the basis for man to live in plenty and peace.

Unfortunately, and this is a fact in Nature too, when one grows roses, he grows thorns as well. It is necessary to recognize for this country that every new technology, in fact every new discovery of science also is ambivalent. Bohr's theory of the atom, Madam Curie's discovery of radio-activity, while unveiling many secrets end laws of nature have caused great concern to man today.

Science and Technology today have put into man's hands enormous energy, speed and power. Power is a scalar quantity and so is a new technology by itself. But the flux of technology (or technodynamics) like the flux of some physical quantity in nature is a Vector.

A vector has a direction, purpose, as it were – destination. It is necessary to define this destination – not just the purpose for a higher standard of living but a better standare of life.

If the tiny atom could cause a great concern to man, the mighty technology could cause even a greater concern and create a greater problem a dilemma and a dichotomy, even a crisis.

CONCLUDING REMARKS – SCIENCE, TECHNOLOGY & MAN

Introduction

Let me conclude,gentleman, by placing before you the fact that for sometime past, the idea has gripped my mind that this country, with its rich heritage of a culture — a scientific culture — a culture based on the Summum Bonum of science — the physical as well as the spiritual — this land of great masters — great spiritual masters on the one hand anu great scientists on the other — this land of Raman and Ramanujam on the one hand and of Sankara and Ramakrishna on the other — this land of Saha, Sahni and Seshadri and Bhaba and Bhatnagar, of Jagdish Bose and Satyen Bose and a host of others in the horizon of physical sciences on the one hand and a similar galary of master minds in the realm of spiritual sciences on the other, could well take the lead in initiating an institution say an academy of physical and spiritual science or better an Academy of Science and Man" — as a Centre of Excellance, for synthesising the fundamentals of physical and spiritual sciences and presenting before the world in general, the rich heritage of values and scientific values of ourour culture based on the experiments and experiences of our ancient masters look to those values through the eye-piece of modern Science – the eye-piece of entropy and present those, values before the mental picture of our younger generations, as to how those values could help to unravel and unfold some of the mysteries of the world within man, a world which man actually is and shall continue to be — a world wherein man gets his shelter and takes his solace in distress where man actually lives and shall continue to live all his life.

With this object alive in my mind I have been going round the country delivering special lectures for "Awakening" the "World within Man" with the message that the Intergration of the Physical Sciences of the World and "Around" Man and the Spiritual Sciences of the "World within" man is the most important intellectual issue and in fact, is a vital necessity not only for man's well being today but for his survival tomorrow.

This is because the storm – the "Entropy storm" and a global storm is there on the Horizon and may at any time, be sweeping on man as a terrible tornado. And a safe way and the scientific way to ride out the storm is to hold firmly on the Rudder and the compass needle, based on the laws on nature. And the law of entropy, that encompasses virtually all activities in nature, indicates that the one way and the only way to ride out the storm is to negate the entropy, to negat the "Number" and the "Quantity" – the "number" of men and the quantity of living the socalled redundant high standard of living, which is a high entropy living.

And there is just one way and the only way to implement the above is to Arm the man from 'Within' – to awaken him from "within" to the vital necessity of the intregation (yoga) of the "Physical" and "Spiritual" – the world around and the world within.

Intgration scientifically means "Summation" – the addition – the Indian word for which is "Yoga".

But how to go about, how to start and initiate the processes.

This question has been haunting my mind for years, the answer eventually wells up rom within "Start with-the Few".

This message from within was inspiring when it occurred to me that it is the few as a law of Nature, that decides the destiny of the many,

The Few Decides the destiny of the Many

It is the few, after all, that decides the destiny of the many. For exarrple

(i) it is the few initial atoms that start tine chain reaction that decide the destiny of the energy released in that chain reaction.

(ii) it is the atoms that decide the destiny of evolution, the Biological Evolution.

(iii) it is the few men that decide the destiny of many men. And sometimes, it is one man, who decides the destiny, who creates the age, who creates the revolution. There is just one Newton, one Einstein, one Tegore, one Buddha, one Shankara, one Remakrishna, one Vivekaranda.

It is just the few and may be even one among you, who may be blessed to do this May be, even one among you, who may be blessed achieve this through some institution or academy, through some centres of excellence say, THE ACADEMY OF SCIENCE AND MAN, beaming out a New Message, leading to New Impacts of Science and Technology towards a New Mature Society with New Economics and New Democracy.

Gentlemen, words cannot move mountain. But words can move men. I felt, let me start row in small bout strong way a Nucleus of a centre of Excellence.

Gentlemen Excellence grows an inevitable law of nature in centres of excellence in contact with excellence.

There are many excellences here — excellent men among you. In fact a few of you have been blessed to be men ‘par-excellence’, who have been blessed with great intellect, high position and power and what is more, great and good heart. It is just even one of you, who can achieve this once you are convinced and scientifically convinced, as I am, of the vital necessity of this Mission.

<u>The Low Entropy — Socio-Scientific-Cultural Mission</u>

I have in my own small and humble way taken up this project as my life's mission for the last several years and have been going round India to say, that this country, (rooted as its people, are, culturally and traditionally to a spiritual base) can be a real force and a dynamic scientific force at this critical stage of human history to shape the industrial culture today into some kind of a ‘Techno-Ethical’ or ‘Physico-Spiritual’ culture tomorrow. Technology we take as (and can show to be) some kind of a tool, to shape this new culture the Nature's culture - based on science, but the Summon Bonum of Science - the science, of the world around (the Physical Sciences) and also the science of world within man (the spiritual sciences).

As some you knew I am seventy now and low in the 'Thermodynamic Potential' of life, rather on a low level - low physical level - with my laden with a lot of entropy.

Nevertheless, Gentlemen I have bequeathed all I have for the 'FOUNDATION FOR SCIENCE AND MAN' and if destiny spares me but a few moe years, may be, I may be able to give a start with your help and guidance.

Gentlemen, I am on the last lap of my life's journey. If destiny summons me before my dreams take shape and before I bid goodbye to you all, may I conclude this with just one appeal.

‘Help keep this Foundation, alive and active’.

Gentlemen, I shall not be here long physically but I hope my memory and my message shall endoure for sometime more the impact of time, for a new Awakening, - an Awakening armed with physical sciences on the one hand of our grert masters in the field of modern sciences and also armed with spiritual sciences of our ancients masters of this land, for the well-being and Elevation of all men - for all generations tomorrow here, there and everywhere.

And with all this Awakening of a low entropy in the world within man this age of science and technology continue to be an unfailing friend to man today, to usher in a new age of 'Sarvodaya' - a universal evolution towards well-being of all tomorrow.

HIGH ENTROPY TECHNLOGY TODAY TOWARDS A LOW-ENTROPY TECHNO-ETHICAL CULTURE FOR A LOW- ENTROPY DEMOCRACY TOMORROW

Technology today reed be fashioned to meet the needs of man on the one hand and to face the challenge of too crisis on the other — the spiritual crisis. The overall future planning — national planning here, there and everywhere - for technology need an approach that permits a co-existence of quantity of life with the quality of life, that helps to develop the science and technology of not only the world-around man with emphasis on ephemeral needs but also the world within man -where man truly exists - to meet his spiritual needs and help thereby to develope a democracy, to build a better world for man to live in 'Plenty and Peace'.

<u>Eduction today is not a Garden but a Jungle</u>

Metal gets educated, as it were through thermo-mechanical treatment, through heat and the hammer of the ancients. Man, similarly gets educated through sights and sounds, through the messages received by the yes and the ears. Bad food and drink damage man. This is well known. But what is not so well known and not so well emphasised is that foul sights and sounds are far more damaging and devastating than bad food or drink. Universities and Higher Institute of, earning I look upon as Gardens of education, where young learners, the young creepers grow to produce fruits and flowers for the service of the nation.

But ask a good gardener to build a good garden on some ground. First, he would fence the ground. Next he will weedout all redundant roots and creepers. Next he toils to till and fertilise the ground suitably and than select the best seed sow that seed in the prepared ground and finally nourish the creeper to grow and yield the fruits and flowers. But here in our Educational Institutions far from fencing and weeding out, far from nourishments in all kinds of sights and sounds. The result is that we do not get a garden of education but a jungle.

FIGURE – I

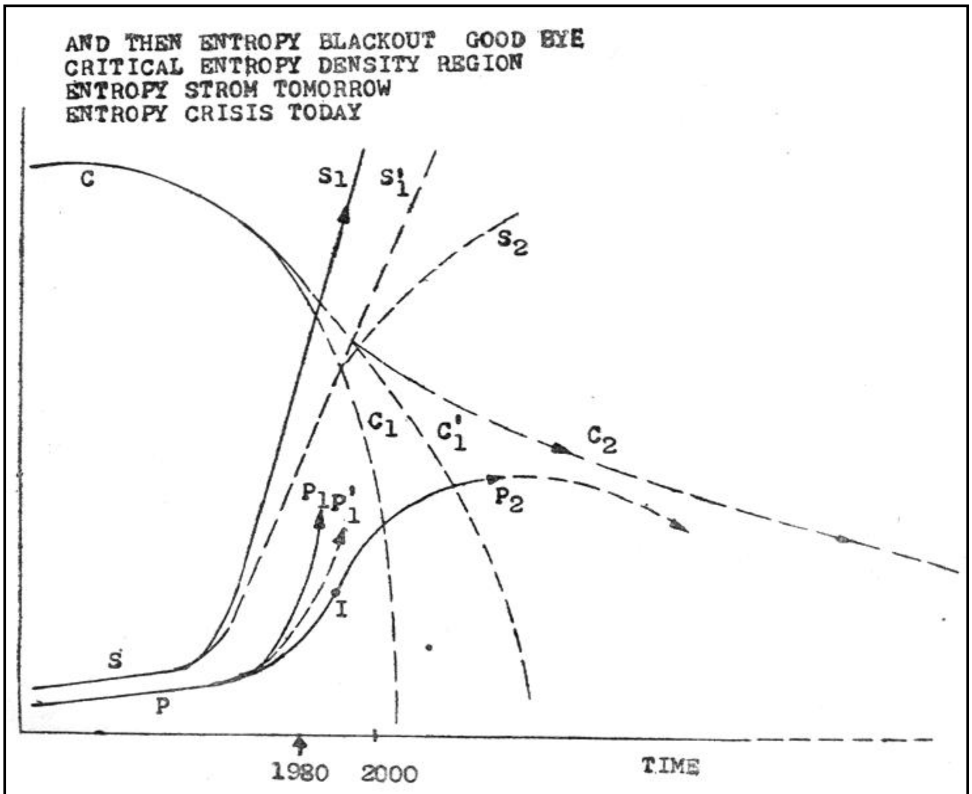
World Around

(Metal) Physical ---- Ecology ----- Physico-Ethical (Man)

Physical Ecology & Environment develops or damages Metal		Ethical Smogs and Smokes more serious and damaging – accelerated Decay + Death
	Ecology	Physical Ecology of Environment develops and damages Man
Thermo-Mechanical Treatment		Ethical Ecology develops and damages Man very much more
		Audio visual Treatment
Physcio-chemical Structure in the world within Metal		Physico-Chemcial Structure in the world within Man
What is Physico-mechanical treatment to metal	is	Audio-visual treatment to Man
The Heat & the Hammer in the environment of Metal	is	The sights and the sounds in the environment of man

FIGURE – II

$C1'$	–	Decay of thermodynamic capital
$C1$	–	Decay of thermodynamic capital (do with alternative effects of recycling, conservation etc)
$P1'$	–	Exponential Production, Population, Pollution, Pathology, Problem
$P1$	–	Exponential production, population, pollution etc. with alternative effects
$S1$	–	Super-exponential rise in Entropy
S_1'	–	Super-exponential rise in Entropy with alternatives
I	–	State of inversion and evolution towards a low entropy society
C_2, P_2, S_2	–	Trends for thermodynamic capital, production and entropy in a low entropy society with low entropy education, low entropy economics and low entropy Ecology leading to a low Entropy Democracy.


AND THEN ENTROPY BLACKOUT GOOD BYE
CRITICAL ENTROPY DENSITY REGION
ENTROPY STROM TOMORROW
ENTROPY CRISIS TODAY
C
S1
S'1
S2
C1
C'1
C2
P1
P'1
P2
I
S
P
1980
2000
TIME

Fig—2

Computers and their Impact on Society

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INTRODUCTION

All of us hear a great deal about computers. They are the centre of continuous public attention and frequent controversy. Does the computer reallythreaten our jobs, our perception of thought and creativity ? Does it overturn our cherised: ideals about learning? Or, on the other hand, is the computer our saviour? Will it free us from all drudgery and turn this vale of tears into a paradise where at the push of a button our every need is met and we are liberated to experience new levels of fulfilment?

These are emotion-laden questions whose calm, ever-handed answers we shall seek through this discussion on computers and their impact on society.

WHAT IS A COMPUTER ?

The computer is a tool that is contributing to advances in virtually all fields ofhuman endeavour. Computers hardware technology is also benefiting from new discoveries in the fields of electronics and physics. Computer hardware consists of all electronic or electromechanical subsystems that make up a functioning computer system. Basically, these machines accept data input, store data, perform calculations and other processing steps, and prepare information output.

Hardware alone, however, is merely one or more boxes of electronic/ electromechanical parts that represent an expense; an equally important perhaps more important consideration in the effective use of computers is the software. Software is the name given to the multitude of instructions, i.e. the name given to programs and routines that have been written to cause the hardware function in a desired way.

COMPUTER DEVELOPMENT

In 1833, Charles Babbage, Lucasian Professor of Mathematics at Cambridge University in England, proposed a machine, which he named the analytical engine. Babbage was an eccentric and colourful individual who spent much of his life in vain attempt to build his machine. Babbage's dream would have incorporated a punched card input, a memory unit or store, an arithmetic unit or mill, automatic printout, sequential program control, and 20-place accuracy. In short, Babbage had designed a machine-a prototype computer that was hundred years ahead of its time. Babbage died in 1871 and little progress was made until 1937.

Beginning 1937, Prof Howard Aiken set out to build an automatic calculating machine that would combine established technology with the punch cards of Hollerith. With the help of graduate students and IBM engineers, the project was completed in 1944. The completed device was known as the Mark I digital computer. Internal operations were controlled automatically with electromagnetic relays; arithmetic counters were mechanical. The Mark I was thus not an electronic computer but was rather an electromechanical one. In many respects Mark Iwas the realization of Babbage's dream. Appropriately, this 'medieval' machine is now on display at Harvard University museum.

The first electronic digital computer to be put into full operation was built as a secret wartime project between 1939 and 1946 at the University of Pennsylvania's Moore School of Electrical Engineering. The team of J Eckert, Jr and J W Mauchly was responsible for its construction. However, as was later determined by a federal judge in an important patent suit, Eckert and Mauchly did not invent the automatic electronic digital computer themselves, but instead derived that subject matter from Dr J V Atanasoff who was a professor of physics and mathematics at Iowa State College.

Vacuum tubes or valves were used in place of relays in the Eckert-Mauchly machine. This computer was called ENIAC (Electronic Numerical Integrator and Calculator) and could do 300 multiplications per second, making it 300 times faster than any other device of the day. Operating instructions for ENIAC were not stored internally; rather, they were fed through externally located plugboards and switches. In 1959, ENIAC was placed in the Smithsonian Institution in Washington.

In 1946, in collaboration with H H Goldstine and A W Burks, John von Neumann, a mathematical genious and member of the Institue for Advanced Study in Princeton, New Jersey (USA), suggested in a paper that (i) binary numbering systems be used in building computers, and (ii) computer instructions as well as the data being manipulated could be stored internally in the machine. These suggestions became a basic part of the philosophy of computer design.

Although these design concepts came too late to be incorporated in ENIAC, Mauchlr' Eckert and others at the University of Pennsylvania set out to build a machine with stored program capability. This machine-the EDVAC (Electronic Discrete Variable Automatic Computer) - was not completed until several years later. To the EDSAC (Electronic Delay Storage Automatic Calculator) finished in 1949 at Cambridge University, must go the distinction of being the first stored program electronic computer.

One reason for the delay In EDVAC was that Eckert and Mauchly founded their own company in 1946 and began to work on the UNNAC (Universal Automatic Computer). In 1949, Remington Rand acquired the Eckert-Mauchly Computer Corporation, and in early 1951, the firstUNNAC-1 (first computer available commercially) became operational at the US Bureau of the Census. In 1963, it too, was retired to the Smithsonian Institution -a historical relic after just 12 years! The first computer acquired for data processing and record keeping by a business organization was another UNNAC-1, which was installed in 1954 at General Electric's Appliance Park in Louisville, Kentucky (USA).

The computers of second generation were introduced around 1959 to 1960 and were made better, faster and with greater computing capacity. The vacuum tube, with its relatively short life, gave way to compact solid state components such as diodes and transistors.

In 1964, IBM ushered in the third generation of computing hardware when it announced its System/360 family of computers. And during the early 1970s, several manufacturers introduced new equipment lines. For example, IBM announced the first models of its System/370 line of computers. These machines continued the trend toward miniaturization of circuit components. Further improvements inspeed, cost, and storage capacity were realized.

REVOLUTON IN COMPUTER TECHNOLOGY

HARDWARE

Hardware technological development has been incredibly rapid as may be seen by an examination of the factors of size, speed, cost, information storage capacity, and reliability.

Size

The second generation computers were much smaller than their predecessors because transistors and other smaller components were substituted for tubes. This size reduction continues even today. It is now possible, through large-scale integration (LSI) of electronic circuits, to pack billions of circuits into a cubic foot of space. Furthermore, each circuit contains a number of separate components. Since 1965, in fact. the average number of components for advanced integrated circuit chip has doubled each year. The boards of today will become the tiny chips of tomorrow. Thus, it is expected that in the 1980’s central processors with power of today's large computers will occupy the space of a shoebox!

Speed

Circuit miniaturization has brought increased speed of operation to the latest computers. Because size reduction shortens distances for electric pulses to travel thus increasing processor speed.

Early computer speed was expressed in milliseconds; the second-generation speed was measured in microseconds; the third and the fourth generation hardware have internal operating speeds measured in nanoseconds. In mid-1980's the machines may have speeds measured in picoseconds.

Cost

There has been a dramatic reduction in the cost of performing a specific number of operations because of the above mentioned technological advances. This in turn has led to a significant growth in the number of computer installations. Also the cost of certain basic components will continue to decline while their speed and performance increase.

Information Storage Capacity

Information may be stored for use by a computer in a humber of ways. The central processing unit (CPU) of the computer holds data and the instructions needed to manipulate the data internally in its primary or main memory section. The primary memory capacity has increased from 20 000 characters in 1950 to 10 million characters in

1975 and it is expected that in the 1980's it will be much greater than 10 million characters. Perhaps even more impressive has been the improvement in mass external online (or secondary) storage devices. The number of characters of secondary online storage has increased from 20 million in 1960 to virtually unlimited in 1975.

Reliability

The reliability of hardware has improved substantially with the substitution of long-life solid state components for vacuum tubes. Much of the research effort directed toward achieving greater reliability has been due to space and missile programs. For example, scientists have been working on self-repairing computers that would remain in operation during unmanned space missions lasting many years. The self-repairing concept essentially involves partitioning the computer into functional blocks and building identical components into each block. Some of the parts are used for processing immediately. Others serve as standby spares. A failure occurring in one component or subsystem would be detected by a statussensing device, and the faulty part would be electronically and automatically replaced with a spare.

The down-to-earth benefits of increased reliability are great. For example, self-repairing computers could be incorporated into the intensive-care monitoring and control systems of hospitals, where a failure could result in certain death. And they would be specially beneficial in those computerized navigational systems that are used to bring aircraft safely in zero-visibility conditions. Although completely self-repairing commercial computers are still on the drawing board because of the additional cost of redundant spare parts, this obstacle will be overcome soon as LSI circuit technology produces lower costs.

Better accessibility of the circuitry enables technicians to get into the problem and quickly effect a repair. Computer circuit boards can be promptly replaced, and equipment down time can be kept to a minimum. It is possible for a malfunctioning computer to be linked to another 'diagnostic' computer in order to determine the cause of the problem. Also, self-diagnostic.or faultlocation features are built into the equipment to help on-site technicians minimize downtime.

SOFlWARE

Unfortunately, when compared with the tremendous hardware advances, the developments in the software area seem less impressive. Today the production of good software is a costly and time-consuming process that generally determines the speed with which computer- based projects are completed. As a result, the investment in proqram ming and systems personnel and in the software the create now far exceeds the investment in hardware in most installations.

Yet there have been significant gains in the development of software. The three basic software categories are :(i) translation programs, (ii) application programs, and (iii) operating-system programs.

Translation Programs

In the early 1950's, users had to translate problem solving instructions into special machine codes for each computer. Such instructions typically consisted of strings of numbers which were quite tedious to prepare.

To ease the programmer's burden, a compromise approach between man and machine was developed which resulted in the introduction of special coding languages that save time and are more convenient to use. Unfortunately, this code is not in the machine's language, and so it does not directly understand others. The programmer and the computer communicate with each other with the help of a separate translation program. The instructions written by the programmer, called the sources program, are then fed into the computer where they are translated. The result of the operation is a set of machine instructions, called the object program, that may then be used to control the processing of problem data.

Almost all problem-solving programs prepared nowadays are first written in languages preferred by programmers and are then translated by special software into the equivalent machine language codes. Continuing efforts are being made to produce software that will permit easier man-machine cornmunications.

Application Programs

The programs written for the purpose ot solving particular processing jobs also come under software. These programs are commonly prepared by each user organization. Many applications programs must, of course, be prepared by users to process tasks that are unique to their particular needs. In the past, however, much programmer time has been spent in duplicating programs prepared by other companies. Recoqnizing the wastefulness of such duplication, equipment manufacturers and independent software companies have prepared generalized application packages for wide use.

Operating-System Programs

As the name implies, the operating system (OS) was initially a set of programs prepared by equipment manufacturers and users to assist the computer operator. It is the function of the operator to load data input devices with cards and tapes, to set switches on the computer console, to startthe processing run, and to prepare and unload output devices. It should notbe the operator's job, however, to waste time doing things that the computer could do more quickly and reliably. House-keeping duties such as loading andunloading input and output equipment, clearing central processor storage locations between jobs, and loading intostorage the next job program and data from the jobs stacked up in a waiting queue are now controlled by the software. Shifting control to specially prepared operating programs thus reduced the operator's work, cut down onthe programmer's drudgery, provided relatively non- stop operation, and therefore increased the amount of processingthat could be accompolished. The name given to the software that aids in performing the housekeepingduties just described is the input! output control system (lOCS) – an important segment of a modem OS.

The objective of current operating systems is still to operate the computer with a minimum of idle time and in the most efficient and economical way during the execution of application and translation programs. But the operating software is now vastly more complex. More sophisticated software has been required to keep faster and more powerful hardware occupied. An example is the development of multi programming - the name given to the interleaved execution of two or moredifferentand independent programsby the same computer.

In recent years, operating system development has also made possible thewidespread introduction of computers with virtual storage capability. Prior to this development, the size of an application program was effectively limited by the size of the computer's primary storage section. This was because the complete program was typically held in primary storage during itsentire execution. If the program size did not exceed the limited primary storage caracity, then there was no problem; if, on the other hand, the task required several thousand instructions, then the programmer might be forced to write t\AIOor more programs tocomplete the job. With virtual storage capability,however, the computer can dividetotal programs into small sequences of instructions called pages. Then only those program pages that are actually needed at a particular time in the processing need to be in primary storage. The remaining segments may be kept temporarily in online storage, from which they can be rapidly retrieved as needed. Thus, from the programmer's point of view, the effective, or, virtual size of the available primary storage may appear to be unlimited.

The incorporation of multi programming and virtual storage capabilities into the OS has, of course, complicated matters. For example, software must keep track of the locations in primary and secondary storage of each of the severalprograms and program segments must remember at what point it should return to an interrupted program, and must, perhaps, assign job priorities to the several takes waiting to be completed. The opemting systems of many of today's computers are integrated collections of processing programs and a master control program that are expected to perform the scheduling, control, loading, and program call-upfunctions.Technology advances in computer hardware and software have both contributed to and been stimulated by a dynamic environment.

THE CURRENT STATE AND A LOOK AT THE FUTURE

Minicomputers and Microcomputers

Until the mid-1960's digital computers remained large in physical size and expensive. Then many special applications emerged which called for a computer of less power than the general purpose business or scientific computer and had no need for a huge assortment of peripheral equipment, very large primary memories, or very high precision. These applications were of myriad types but genemlly had in common financial constraints precluding the dedication of very expensive systems. The rapid improvement of semiconductor devices in performance and their dramatic reduction in size, in cost, and in the power required to operate them provided the answer: the minicomputer. While there is no perfectly precise definition of a minicomputer, it is genetally understood to mean a computer whose main frame-central processor and primary storage unit – is physically small, that is, no more than a fewcubic feet, has a fixed word lenght between 8 and 18 bits with 16 rapidly becoming the industry standard, and costs less than $US 10 000 for the central processor with 4 096 words of primarymemory. The maximum amount of primarystorage availableoptionally in minicomputer systems ranges from 32K to 128K words.

A variety of peripheral equipment has been developed especially for use in systems built around minicomputer maintrames ;they are sometimes referred to as minipherals and include magnetic tape cartidges and cassettes, paper tape readers and punches, small disk units, and a considerable variety of printers and consoles.

As the operating environment for most 'minis' is far less varied and complex than those of large machines, the varietv and capability of the software furnished are correspondingly diminished. The operating systems usually provide systems access to only a single user, in a few cases, a small number of users, at a time. The higher level languages available are frequently limited to FORTRAN and/or BASIC, although withthe large number of minis available today, one can, for anyone of the most popular languages, find one or more minis on which it is available. Since many minisare employed in real time systems, they are usually provided withopemting systems specialized to this purpose.

Among the areas in which minicomputers have found application are computer communications, numerical machine tool control and manufacturing automatic product and system test equipment, and data collection from manual data sources via terminals and other conventional input means as well as from instruments which are read directly by the computer.

The frequent employment of minicomputer systems in real-rime applications has influenced other aspects of their design. They usually possess the hardware capability to be connected directlyto a large varietyof measurement instruments or to analog to digital converters for those instruments are not themselves providing digital outputs. The outputs of these instruments can be scanned or multiplexedintomemory, there to be operated upon by the prograrn, on a repetitiye basis as determined in some program loop, on the basis of real time clock values read by the proqrarn or as the result of conditions that generateprogmm interrupts.

The early 1970's saw the advent of the latest product to appear in the computer market place: the microcomputer. The microcomputer achieves the ultimate in one sense; its central processor, called microprocessor, is fabricated on a single semiconductor device, ie, the thousands of individual circuit elements necessary to perform all the logical and arithmetic functions of a computer are manufactured as a single monolithic chips, a fraction of a square inch in area. A complete microcomputer system consists of a microprocessor, memory and peripheral equipment.

The processor, memory and electronic controls for the peripheral equipment are usually assembled on a single ora fewprinted circuitboards. One can put together systems using microprocessors which, at the upper end of their capability class, crowd, and in fact now overlap, what was until very recently the lower end of minicomputer system capability. Microprocessors, of which several dozen varieties are currently marketed, generally have somewhat simpler and less flexible instruction sets than minis and are typically perhaps 10 or so times slower. Different microprocessors are available with 4-, 8-, 12-, and 16-bit word lengths, Minis can be equipped with much larger maximum memory size than micros and are capable of operating with a far greater variety of peripheral equipment.

One use, at the low end of rnicroprocessors line, has made its presence felt almost as ubiquitously as the transistor radio is the handheld calculator. These little machines consist of a Land 4-bit word length microprocessor, one or a few memory registers, a display and a simple keyboard all in a light plastic case. More complex calculators are now entering the market which can also enter stored program steps on magnetic strips and v.hk:h contain more data storage registers as well as providing hard-copy output The line between calculators and microcomputer systems will doubtless continue to blur as will the line between microcomputer system and minicomputer systems.

The extremely low price of microprocessors has opened up entirely new areas of computer applications. It is now feasible to use only a minute fraction of the computer's capability in a particular system application and – still be way ahead, financially, of any other way to get the job done. Although the software available for most microcomputer systems is very limited, far more than is the case for minis, this does not discourage their use in the many high volume, fixed applications for which programming is essentially a one-time effort.

Computer Networks

Many users may be simultaneously connected to a computer with the attendant feeling of making simultaneous use of its resources. This is called time-sharing; in effect, many users, each in turn, getting a very small share of the system's total capacity. When everything is working right, these tums are so frequent that the service seems continuous. There comes a point, however, when with sufficiently many active users, any system will saturate and delays willbecome first perceptible then appreciable and ultimately intolerable. We clearly cannot go on dividing this finite, large, computational resource among more and more users indefinitely. Computer networks (systems consisting of several computers interconnected by electronic communication media) were introduced, among other reasons, to deal with this situation. A system which can readily switch a user from a very busy computer to a less busy one will clearly result in a shorter average response time for all users. These are nothing more than load distribution techniques which have long been practised in power and communication systems. Distribution of central process unit load isJhowever, by no means the only reason computer networks have, since the late 1960s, undergone intensive development and subsequent very rapid growth.

Primary memory requirements can exceed a system's addressing capability. The organization of a system's input/output controls similarly limits the amount of secondary and tertiary storage which can be 'hung' on. Thus when the size of the user data basis becomes too large, a system can become ineffective even though it might still possess ample CPU capacity.

Also, some installations possess specialized human and equipment resources which are of only occasional but still significant use to individuals located long distances from those installations.

Computer networks also serve, particularly in the military, to allow the physical dispersal of hardware and data so as to render an overall network more secure against attack, or more prosaic failure modes, as well as facilitating the pyramiding of data up command channels. The communication lines and equipment that interconnect the computers in a network can so organized as to contribute almost negligibly to the degradation of the reliability of the overall system, that is, to the likelihood that computers in the network become inaccessible to users.

Supercomputers

By the end of the 1950’s, detennined efforts were underway to produce computers with instruction execution rates and memory speeds well above those generally thought to be needed by the typical business and engineering users. These computers, called supercomputers, were produced to satisfy the demands made by new and more complex applications. The earliest supercomputers (mostly manufactured by IBM and UNNAC) were built in small numbers, but the hardware and design techniques that resulted from these development efforts were to profoundly influence the commercial product lines of both companies. In the late 1960's and early 1970's, the supercomputers were the Control Data Corporation (CDC) 6600 (followed in succession by their current supercomputers, the 7600 and 8600) and the several model 90s in the IBM 360 series. The latest supercomputers are the COD STAR, the CRAY-1, the Texas Instruments (TI) ASC, and the ILLIACIV designed at the University of Illinois (USI\) and manufactured by the Burroughs Corporation.

TOMORROW’S SYSTEM

Since expanded processing capability is essential in coping with tomorrow's complex society, it is not too far-fetched to say that most of today's computers eventually will be replaced by quite different machines.

This transformation will be brought about by what is prosaically referred to in the data processing Systems industry as dae base management. Functionally, the management and utilization of a common data base is quite simple and straightforward, requiring only that common data used by various departments in a corporation be kept current so that users can have access to it for their own specific needs. This chore involves a huge amount of data that has to be located, extracted, and disseminated fast enough so that it does not slow the using departments; however no really complex processing is needed.

Since data base management is so straightforward, why then will it be beyond the capability of our present computers? The truth is that although today's computers are wonderfully efficient at performing complex mathematical calculatrons, they are woefully deficient at all the mundane operations of storing, sorting and fetching all tasks that are required in data base management and that constitute 90% of what one asks computers to do today. Even though the computer industry has gone through three generations of development, it has designed machines optimized for only 10% of the workload.

Further more, the disparity between workload and capability will growwider in the years ahead. As processing becomes an' ever more pervasive part of our everpdaylives, the newapplications will have little need for complex arithmetic calculations. Rather, they will have a simple primary need-to query a data base and get a specific answer as quickly and cheaply as possible. Simple as that may be, it will present virtually Insurmountable proolems for the computers we have today.

There is no question that an entirely new type of processor will be developed in the next five to ten years and that this new machine will be optimized for data base management functions. Wth the lower hardware costs resultinq from large scale integration devices, we will no longer be economically required to force-fit a nurnber-crunching computer to data base management functions that will so predominate. The small percentage of the tasks requiring complicated calculations will be handled by stripped-down versions of today's computers.

What will such a system look like? Well, we can safely predict that a typical system will be quite large, with geographically dispersed elements probably linked by voice-grade communication links. The processing elements will undoubtedly be distributed with intelligent terminals accessing a common database.

The system will be designed so that users will be able to enter data and access the data base using free-from English commands. The intelligent terminals will provide cues on the display screen so that even relatively unskilled operators will be sure to enter all needed commands and will be alerted when theyhave made input errors.

COMPUTER APPLICATIONS

The computer was developed over alongperiod of time through the efforts of many people throughout the world. It did not mysteriously appear and insidiously begin assuming the countless tasks that it now performs, People thought of the ideas that evolved intoa computer. People make it possible for computers to be useful to society. People determine whatjobs are programmed for computers and people develop the programs that control computers. Furthermore, people have brought about the -growing role played by computers in our lives. So it falls to all ofus to become aware of some of the more important ways in which people are using computers to influence other people.

Over the past 25 years computers have had — as they continue to have — an ever-increasing impact on the activities performed by business organizations and on the tasks that managers perform within these organizations. Some of these impacts have been felt in other types of organizations.

COMPUTERS IN GOVERNMENT

Existing broad social and political problems such as creeping wban decay, air and water pollution affect our everyday lives. In addition to attacking these problems, greater attention must also be given in the future to such social needs as more comprehensive healthcare, better transportation planning and improved public safety. Governmental agencies at all levels in our society are involved. But because of the interrelated nature of many of the existing social needs and because of the magnitude of the economic resources which must be made available to deal with many of the problems, citizens expect the government to provide directions and resources to effect many of the necessary improvements. In seeking solutions to difficult social problems, the government administrators need timely, accurate, and relevant information.

Computers can therefore be used in the government for : (i) planning and decision making, (ii)control, and (iii)law enforcement purposes.

National Informatic Centre (NIC)

A National Informatic Centre has been set up at New Delhi with the long range objective of establishing an Union ministries and departments. The NIC,which willact as a focal point for developing, managing and operating information system with the Government, is expected to be very valuable for decision making and development planning.

As the decision-making bodies like the Cabinet, the Finance Ministry and the Planning Commission would require up-dated information continuously from all administrative departments, the NIC is creating a service infrastructure to enable the required information to be available through computer tenninals at their own locations by simply hooking on to the network. This would give them timely information without duplicating efforts.

The network is being organized around a giant host computer which is connected toa fewfront-end minicomputer systems. These will act as the focal points for sector-wise correlation of sub-data bases, The terminals,which will be housed in various concerned departments, will be connected to these minicomputers. The terminals will have the capabilityto function independently of the network, while processing confidential information.

COMPUTERS IN BUSINESS AND INDUSTRY

Accounting Applications

Among the very first business tasks programmed on a computer was the computation of a payroll. This application was a natural for a computer because it was an easily defined task requiringrepetitionsofvirtuallythe same sequence of instructions for each employee. Today, managers ofbusiness operations often consider acquiring computers simplyto handle the payroll and many related record-keepings. Computerizing payrolls is probably the rnostwidely used application ofcomputers in the business world. In addition, entire computerized accounting systems have been established that initiate and maintainjournals and ledgers.Accounts in various ledgers are queried to prod uce an endless variety of reports. And even computerized auditing systems have been developed.

Computerized Invoicing System

Besides making available accurate reports of the financial status of a company, it is very important to let customers know how much they owe for goods or services received. Generally, the sooner people are notified,- the sooner they pay their bills, and the money becomes available to the firm to use in the best possible way to generate more income. An accurate, up-to-date record of sales and customers is the key to a timely invoicing plan. A very effective way to make such a plan operational isto use a computer.

Inventory Management

An up-to-date record of all merchandise on hand, itscost, itscurrent value, its present location in the company, as well as complex knowledge of what items have been ordered, when they will be aoailable to customers, and their cost, are essential to any system designed to maintain an optimum inventory. That is where computers enter the picture. If appropriate programs are written,that informationcan be retrieved and used to generate reports of the type needed for inventory control.

COMPUTERS IN THE FACTORY

Computers have affected business and industry in yet another way; they have made the manufacturing process more automatic. For many yearsmanufacturers have used- parts making machine that are 'numerically controlled by punched paper tape or punched cards. Today, an even more complex process,controlling virtually every aspect of many manufacturing operations is available.For example, those industries in which one continuous process yields the completed product, such as in the refining of oil products from crude oil, the prod uction of sugar prod ucts from sugarcane, the manufacture of steel trom iron ore, the creation of various glass products from sand, and the processing of fertilizers from minerals, all lend themselves to computerization. The manufacturing process itself is essentially dependent on the control of simple devices such as valves or heating mechanisms. These devices must be accurately controlled within relatively narrow ranges, but aside from that the processes are verysimple.Thus there are entire factories whose many functions are controlled by a computer.

Human beings are needed only to supervisethe overalloperation to ensure that no gross problems develop. Properly programmed computers controlling factories in that way would allow for necessary variations in the procedureand adjust related operations accordingly.

Of course, appropriate sensing devices would monitor conditions all along the production line,feeding their information to the computer, The computer would coordinate allactivities by sending the necessary signals to control devices.

In non-continuous manufacturing situations, likethe separate manufacturing of the thousands of parts that go into an airplane, computers are most effective in controlling the factory's resources and in schedulingthe production of parts so that they are ready for incorporation into the major product at the appropriate time. In such manufacturing situations, following reasons have been given for computerizing the factory process : (i) to reduce the price of the product, (ii)to increase the uniformity of the quality of the product, and (iii) to increase job satisfaction.

The last of these reasons is somewhat surprising, but it is related to the need for people to supervise operations, program the machines and manage the various aspects of manufactunng rather than perform the hopelessly dull and routine tasks often associated with mass-production factories.

COMPUTERS IN MEDICINE

Physicians think of their data processing uses as falling into two categories: administrative data processing and clinicaldata processing. Administrative data processing includes the usual accounting operations with slightmodifications to meet the specific needs of hospitals. However, the clinical data processing needs are - quite different from anything encountered thus far in our discussion.

Medical Records

Whenever a person becomes a patient in a hospital, records of previous symptoms, treatments prescribed, and reactions to treatments follow the person during his/her stay in the hospital. Medical records have so far been paper records. Physicians have writtentheircomments on paper, which becomes a part of the file. Hospital records are added to the file, and the entire collection becomes a medical history of the patient.

Because it is often difficultto quickly extract the key data in a person's medical record, and because a physician's time must be shared by so many patients there have been efforts to develop systems for computerizing medical records. In some of the latest systems, physician's reports are scanned by specially trained people for key phrases which are then used as mdexmg devices when the report is entered into computerized files.The keyphrases can be used by physicians to query computer files in subsequent sessions. At the patient and retrieve information that will help them assess how the patient is responding to treatment.

Pharmacy Records

The pharmacy record subsystem of a medical information system is the record of all medications used, prescribed or known to be dangerous to ,each patient. Rapid processing of prescriptions can almost always result in greater cornfort for a patient in a shorter time, and could even affect the recovery time. Quick access to information about drugs to which the patient is allergic could mean the difference between life and death.

Accurate, up-to-date historical records of medications used by patients could also have a direct bearing on recovery time.

Radiology Subsystems

Radiology is that branch of medicine that uses radioactive materials and Xrays in diagnosis.Computers have been very helpful to radiologists. In fact, in some systems the data from X-rays are transformed into digital signals, transmitted to a computer and analysed by computer programs designed to detect various abnormalities and stored for further analysis at a later time. The results of the computer analysis are immediately available to the physician for diagnosing the patient's illness.Some computerized radiology subsystems are also used in what is sometimes called nuclear medicine. This refers to the use of a radioactive tracer material introduced into the body. This tracer emits gamma-rays that can be detected and used in the analysis of the patient's illness. Sometimes the gamma-ray detectors are connected directly to a computer where a special program analyzes the data. Such computer analysis are often more detailed than those any physician could possibly conduct, and their results are always immediately avilable, a factor that could be critically important in some cases.

Clinical Laboratory

In its less sophisticated form, the clinicallaboratoryportion of the medical Information system stores and analyses the results of laboratory tests. That is, fluidand tissue samples are taken from patients and tested in conventional ways by medical technicians.The results of tests are keyed into terminals by the medical technician, then stored as part of the clinical data and are subject to analysis by a computer programme analysis program identifies pathological problems and makes the information available to the physician upon his/her request.

In more automated forms, devices that actually conduct the necessary tests are connected directly to the computer. A nurse may be present to actually take the fluid or tissue sample arid then deposit the sample in a special place inthe machine. Then by subjecting the samples to various laboratory tests, all automatically, the chemical natures of the samples are detected by special devices and the results sent on to the computer.

Some Unusual Uses of Computers in Health Care

Acomputer isbeing usedto assist in brain surgery. Special devices for sensing the electrical activity in the brain are used to help the surgeon detect the exact place where corrective surgerv must be made. Signals from these special Sensors are transmitted to a computer which, in turn, produces output on the screen of a terminal in the operating room that shows the surgeon where the problem is located.

Computers are being used to help deaf people to hear and blind people to see. In case of the deaf, microphones are used to pick up sounds. The sounds are converted into digital signals that are then sent to a computerfor processing. The computer sends electrical signals to the patient via wires attached to area near the auditory nerve. In a number of cases the patient 'hears' sounds viathe intermediary, the computer. Similarly research has been done in the area of sight for the blind with the equipment modified to detect light waves rather than sound waves. Computers may soon help such disadvantaged people to function in much more normal fashion.

COMPUTERS IN THE EDUCATIONAL ENVIRONMENT

One of the first and persistently growing applications of computers to education has been in record-keepmg of scholastic records.

Another growing application of computers to education has been computer assisted instruction (CAI). In a typical CAI setting,the student sitsat an online device (usually either a typewnter terminal or a visual display) and communicates with the program in the CPU. Interaction may take place in the following way: (1) the computer presents instructional information and questions; (2) the student studies the information or instructions presented, answers the questions and, perhaps, asks questions of his own; and (3) the computer then accepts, analyzes,and provides immediate feedback to the student's responses, and it maintains records of his performance for evaluation purposes.

OTHER APPLICATIONS

There are many other applications of computers including the use of computers in communications and criminal justice. Computers are now widely being used in mtching of telephone circuits. Such computer-controlled systems can identify available telephone circuits much more rapidly than human operators.

Computers are also a vital component in communication systems that employ earth satellites designed spedficaily for communication purposes. That role will become more significant in the near future.

Instead of telephone-line circuits,the computer-directed system will select appropriate microwave circuits on which to transmit signals that will complete a call. Signals could be sent between any two points on earth having a straightline access to a satellite.Undoubtedly such a communication system would permit nearly instantaneous information exchange among people.

Of all systems at work in any country, the one that every lawabiding citizen hopes works well even if all others start faltering is the criminal justice system. No one wants to be unjustly jailedor penalized. Hence a number of information processing systems can be used by this far-reaching force in our society. Computers are already being used to maintain records of wanted persons, stolen property and criminal events in a way that is helpful to lawenforcement personnel who need such information. Also a number of systems of computer-aided identification are used by various law enforcement agencies.

POSSIBLE NEGATIVE IMPLICATIONS OF COMPUTER USAGE

It should be apparent by now that computer systems have taken on increasingly responsible tasks in many organizations and are now performing vital functions in our society. Thus, it is essential that in the data processing steps performed by computers vital and relevant data are not lost or stolen, errors are not introduced into the data, and data are not stored, retrieved, modified, or communicated without proper authorization. In other words, we emphasize that it is essential that the interrelated issues of data integrity, data security, and personal privacy be given careful consideration in the design anduse of computer systems.

DataIntegrity Issues

The data processing steps that must becarried out properly if data integrity is to be maintained are originating recording, classifying, sorting and calculating. Some of the possible ways in which the insensitive and/ or thoughtless performance of these steps may lead to undesirable social results.

More 'computer errors' may be attributed to inaccurate and incomplete data input than to either hardware failure or incorrect software. Unintentional mistakes in filling out input forms, keying records, coding accounts, etc are common enough in any record keeping system. But the consequences may be more serious in a computer based system because there may be fewer individuals to catch errors and the speed with which inaccurate information is made available to system users may be much faster than the speed with which errors are detected and corrected.

Classifying and sorting input data accordingto some commonly defined and consistently organized coding scheme can lead to more standardized information systems.And the standardization now taking place in organizations may result in economies and increased efficiency. But standardization may also lead to unwanted depersonalization. As an individual comes in contact with an increasing number of computer systems, the use of numerical codes for identification purposes may also be expected to increase. Although individuals may understand that their being treated as numbers can lead to standardized and efficient computer usage by organizations, they may wish that it were not so. Depersonalization is something that individuals are likely to have to submit to more often in the future.

Data Security Issues

In addition to the need to maintain data integgnty, businesses must also maintain the security of data if adverse effects are to be eliminated. In other words, the data processing steps of summarizing, communicating, sorting, retrieving, and reproducing must also be controlled if negative consequences for organizations and for people are to be avoided. Itdoes not help an organization if its secret product data that falls into the hands of a competitor are accurate. And it does not help much for people to know that information is not secured and protected against theft, fraud, accidental or malicious scrutiny, manipulation, and/or destruction.

Problems with the security of information systems existed before and during the time that computers first began to replace file cabinets. But the vulnerability of computer systems has increased substantially in recent years, and so the security issue has become much more important. Earlycomputers were generally located in self-contained installations, were accessible to a relatively small number of specialists, and were employed to process batches of data in a single stream. As computer systems increased in number and became more sophisticated, however, multiprogrammingand multiprocessing concepts became available,many more individuals had access to information systems, the use of shared resources and jointlyused data became common, and remote access to direct interaction with a distant computer became a routine operation for even casual users. Such an environment has obviously increased the difficultyof maintaining security. But in addition to security difficulties caused by easy access by many people, the wlnerability of systems has also increased because (1) the information to be found in a relatively complete and up-to-date data bank may be sufficient value to provide the incentive for outsiders to seek access to it, and (2) an increased number of individuals has now been trained in computer science and in the skills required to program, penetrate, and manipulate computer systems.

Since the security ofcomputer systems was recognized as a sufficient problem only in' recent years, the computer hardware in general use today was not designed with security provisions in mind. Thus, the security provisions that do exist are found in software and in the organizational policies, administrative proced ures, and data processing controls that may exist in the particular system.

The Privacy Issue

Both data integrity and security are needed to protect an individual's legitimate right to privacy, ie, to protect the right of an individual to limitthe access to personal and often sensitive information to persons authorized to use it in the indtvidual's best interests.

With an ever-increasing number of govemmental agencies effectively using computerized data files,the possibility of consolidating the various files becomes a matter of concem. The possibility of linking all govemment files posses a serious threat to the citizen's right to privacy.

How could such filesbe consolidated? If, whenever a file were established for a given person, the same identifying data element were always used for records associated with the person, then a computer program could easily be written to search all files for records containing that identifying data element.

It is important that before computerization of intelligence and investigative reports is permitted, rules to protect privacy at least as sophisticated as the ones proposed for record information must be required.

Legislation must be enacted to provide some protection of the individual's right to privacy but this should not be considered enough to permit relaxation. Concemed citizens must constantly keep informed on this matter and take appropriate action to see that no encroachments are made on individual privacy.

Technology Helps to Explain the Wisdom of Sankara

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शौनको ह वै महाशालोऽङ्गिरसं विधिवदुपसन्नः पप्रच्छ
कस्मिन्नु भगवो विज्ञाते सर्वमिदं विज्ञातं भवतीति ॥३॥

महाशालः The great householder शौनकः the son of Sunaka ह वै that famous विधिवत् properly, in the manner laid down by the scriptures उपसन्नः having approached अङ्गिरसम् Aṅgiras पप्रच्छ asked नु well. भगवः Sir कस्मिन् what विज्ञाते being known सर्वम् all इदम् this (world) विज्ञातम् known भवति becomes?

3. Saunaka,that famous householder, once approached Angiras in the manner laid down by the scriptures, and questioned, "Sir, what is that, knowing which everything in the world becomes known ?" .

CHAPTER ONE: SECTION ONE

MUNDAKOPANISAD

RESEARCH IN MODERN PHYSICS IN HARMONY·WITH ANCIENT PHYLOSOPHY

354. ஐயுணர்வு எய்தியக் கண்ணும் பயமின்றே
மெய்யுணர்வு இல்லா தவர்க்கு.

Five-fold perception gained, what benefits accrue
To them whose spirits lack perception of the true?

Even tbose who have all the knowledge which can be
attained by the five senses. wlll derive no benefit from it, if
they are without a knowledge of tbe true nature of things. 4

I. Introduction

The purpose of this paper is to explore the relationship between the concepts of modern physics and the basic ideas in the philosophical and religious traditions of Hinduism. We will see how the two foundation of 20th Century physics - quantum theory and relativity theory - both force us to see the world very much in the way a Hindu (or a Buddhist or a Taoist) sees it. In other words, one can say that modern physics, particularly in the phenomena of the submicroscopic world leads (The properties and interactions of the subatomic particles of which all matter is made) us to a view of the world which is very similar to the views held by mystics of all ages and traditions.

Starting with a brief description of the evolution of western science, we present the recent developments in 20th Century physics in the fields of quantum theory and relativity theory. Then a brief sketch of the Eastern philosophies is presented. The final part deals with the parallels in modern physics and ancient philosophy and how strikingly close are the meanings conveyed in what the scientists and mystics have stated. We will see that there is essential harmony between the spirit of Eastern wisdom and western science.

However, in order to study the parallels between modern physics and eastern mysticism, the question arises as to how one can make any comparison at all between an exact science expressed in highly mathematical language and spiritual disciplines mainly based on meditation. What will be compared are the statements made by scientists and eastern sages about their knowledge of the world. Two important points would thus be the nature of the knowledge involved and the language in wqich this knowledge is expressed.

Scientific knowledge is rational. It belongs to the realm of the intellect, whose function it is to discriminate, divide, compare, measure and categorize. Abstraction is an important feature of'this knowledge, because in order to compare and to classify the immense variety of shapes, structures and phenomena of the rational world, one cannot take all their features into account. The phenomena not taken into account may either have such a small effect that their inclusion would not alter the theory significantly but could increase the complexity of mathematics or they may be left out simply because they are not known at the time when the theory is built. Newton's 'classical' mechanics illustrates this point most well. The effects of air resistence (or friction) for example are generally not taken into account in an idealized Newtonian model because they are usually very small, nevertheless important in an actual or real problem. But, apart from such omissions, Newtonian mechanics was for a long time considered to be final theory for, the description of all natural phenomena until electric and magnetic phenomena were discovered. The discovery showed that the model was incomplete and that it could be applied only to a limited group or phenomena. Today it is known that the Newtonian model is valid only for objects consisting of large numbers of atoms (i.e. essentially the notion of solid bodies) and only for velocities which are small compared to, the speed of light. When the first condition is not given, classicaL mechanics has to be replaced by quantum theory; when the second condition is not satisfied, relativity theory has to be applied. This, of course, does not mean that Newton's model is 'wrong' or that the other models are 'right'. All these models are approximations which are valid for a certain range of phenomena. Beyond this range, the models have to be either improved or replaced by better ones. Thus rational knowledge which is the knowledge of science based on abstract thinking, is only like plane maps of reality in which all things are reduced to their general outlines. Thus,in modern physics, it is true, as in the words of Werner Heisenberg, 'that every word or concept, clear as it may seem to be, has only a limited range of applicability'[1].

On the other side, what the Eastern mystics are concerned with is the 'absolute knowledge', that is, a direct experience of reality which transcends not only intellectual thinking but also sensory perception. As is written in Katha Upanishad[3]

अशब्दमस्पर्शमरूपमव्ययं
तथाऽरसं नित्यमगन्धवच्च यत् ।
अनाद्यनन्तं महतः परं ध्रुवं
निचाय्य तन्मृत्युमुखात् प्रमुच्यते ।। १५ ।।

यत् which अशब्दम् without sound, अस्पर्शम् without touch, अरूपम् without form, अव्ययम् imperishable, तथा so also अरसम् without taste, नित्यम् eternal, अगन्धवत् without smell च and (भवति is) अनाद्यनन्तम् without beginning or end, महतः than Mahat परम् beyond (superior to), ध्रुवम् immutable तत् that (Ātman) निचाय्य having realized मृत्युमुखात् from the jaws of death प्रमुच्यते one is released.

15. Having realised that[i] (Ātman) which is soundless, touchless, formless, imperishable, and also without taste and smell, eternal, without beginning or end, even beyond[2] the Mahat, immutable, — one is released[3] from the jaws of death.

Ccmplete apprehension of this knowledge is not only the care of Eastern mysticism, but is also, the central characteristic of all mystical experience. This ultimate reality can never be an object of reasoning, can never be adequately described in words because it lies beyond the realms of the senses and of the intellect. The Upanishads say about it[3]

नैव वाचा न मनसा प्राप्तुं शक्यो न चक्षुषा ।
अस्तीति ब्रुवतोऽन्यत्र कथं तदुपलभ्यते ।। १२ ।।

12. (That Ātman) can never be reached by speech, nor by eyes. nor even by mind. How can it be realized otherwise than from those[1] who say that it exists?

Although physicists are mainly conce rned with rational knowledge and mystics with intuitive knowledge, both types of knowledge occur in both fields. Ordinarily however, in physics. knowledge is acquired through the process of scientific research like gathering experimental evidence, correlating these experimental facts with mathematical symbols and thus developing a mathematical symbols and thus developing a mathematical model on a theory and finally to use the theory to predict results of further experiments. But intuitive insights could and do indeed occur to scientists, which would be then tested for validity. Similarly, there is a rational element in eastern mysticism also, as would be seen from the highly intellectual schools of Hindu Vedanta or the Buddhist Madhyamika. As mentioned, however, direct mystical experience is at the core of all schools of eastern mysticism. All knowledge is based firmly on this experience.

This firm basis of knowledge on experience suggest a parallel to the firm basis of scientific knowledge on experiment. The experimental stage in scientific research seems to correspond to the direct insight of the eastern mystic and the scientific models and theories correspond to the various ways in which this insight is interpreted. The scientists and the mystics have developed highly sophisticated methods of observing nature which can be accessed by a layman only after years of training.

Just like a physicist realizes that all models and theories are approximate and do not explain the whole realm of natural phenomena at once, the eastern mystic too is well aware of the fact that all verbal descriptions of reality are inaccurate and incomplete. Hinduism transends the problem of communication of this experience of reality by using myths, metaphors, poetic images, similes and allegories. The vast and rich Indian imagination has created a number of gods and goddesses whose incarnations and exploits are the subjects of some of the greatest and beautiful tales of the world. These are the vehicles through which the doctrines of Indian philosophy and mystical experience are conveyed to the layman. The paradoxical nature of reality is clearly brought forth in these epics and stories. And this is one of the roots of the relation of modern physics to eastern philosophy. The study of the world of atoms forces physicists to realize that the common language to describe the atomic and subatomic reality is inadequate and might seem paradoxical and full of contradictions. For example the dual nature of light, i.e, nature of electromagnetic radiation to behave like waves to produce interference and diffraction phenomena and also to behave like particles to produce photoelectric effect etc. In eastern mysticism, an the other hand, it has always been realized that reality transcends ordinary language and the sages of the east were not afraid to go beyond logic and common concepts. This has been the realization of modern physicists a1so, especially in the world of submicroscopic particles which can be studied only through their reactions with other particles. The subatomic world itself lies beyond our sensory perception. Thus the same idea of reality or matter is perhaps conveyed to the Hindu by the dancing god 'Nataraja' as to the physicist by certain models of quantum of theory. Both are models to describe the reality as experienced by the author.

II. EVOLUTION OF SCIENCE

The roots of physics are to be found in the first period of Greek philosophy in the sixth century B.C., in a culture where science, philosophy and religion were not separated. Further developments of western science had to wait until the Renaissance and in the late 15th Century, the study of nature was approached in a truly scientific spirit, after the discoveries of Galileo and much later of Newton. From the second half of the 17th to the end of the 19th Century, the mechanistic Newtonian model of the universe dominated all scientific thought. This model constituted the solid framework of classical physics, providing a formidable foundation to science for almost three centuries. In Newtonian mechanics, physical phenomena took place in the 3-dimensional space of classical Euclidean geometry. It was an absolute space, always at rest and unchangeable. All changes in the physical world were described in terms of a separate dimension called time, which again was' absolute, having no connection with the material world and flowing smoothly from the past through the present to the future. The elements of the Newtonian world which moved in this absolute space and absolute time were material particles, small, solid and indestrictible objects, out of which all matter. is made. All physical events are reduced to the motion of these material points in space, caused by their mutual attraction i.e. by the force of gravity. Following Newton's derivation of the equations of motion, his theory was successfully extended to the motion of fluids, vibration of elastic bodies and to theory of heat. This view of nature is thus closely related to a rigorous determinism.

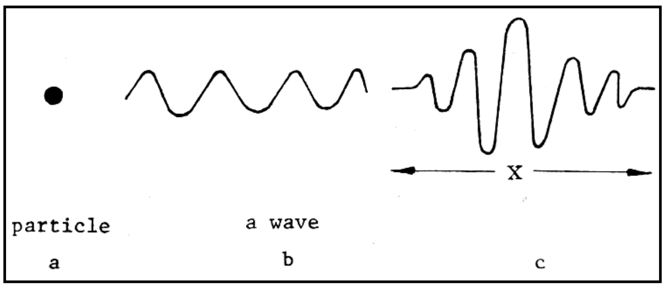
First limitations of the Newtonian model became apparent in early nineteenth century, with the discovery and inv.estigation of electric and magnetic phenomena by Michael Faraday and Clark Maxwell. Instead of interpreting the interaction between a positive and a negative charge simply by saying that the two charges attract each other like two masses in Newtonian mechanics, they found it more appropriate to say that each charge creates a 'disturbance' in the space around it so that the other charge, when it is present, feels a force. This condition in space which has the potential of producing a force is called a field and it exists whether or not another charge is brought in to feel its effect. It is created by a single charge and it exists whether or not another charge is brought in to feel its effect. This theory was called electrodynamics and it was soon after realized that visible light, a small fraction of the whole electromagnetic spectrum is a rapidly alternating electromagnetic field travelling through space in the form of waves.

Until the beginning of 20th Century Newton's, mechanics and Maxwell's electrodynamics were succes sfu lLy applied to different phenomena. Sweeping changes however took place in the first three decades of this century, which, shattered the principal concepts of the Newtonian mechanics including the concept of length and time, the equations of motion (and the conservation principles), the ideal of an objective description of nature and the strictly causal nature of, physical phenomena. These changes were initiated by Albert Einstein's two revolutionary trends of thought published in his articles in 1905. One was his special theory of relativity and the other was the there of atomic phenomena. Although motivated by a desire to gain deeper insight into the nature of electromagnetism, Einstein, in his special relativity theory extended and generalized Newtonian mechanics as well. He correctly predicted the results of mechanical experiments = over the complete range of speeds from u/c = 0 to u/c = 1 (u being the. speed of the moving object and c the speed of light). The low-speed Newtonian environment was thus a special case of a more general theory.

According to relativity theory, space is not three-dimensional and, time is not a separate entity. Both are intimately connected and form a four-dimensional continuum, 'space-time'. Further, there is no universal flow of time as in the Newtonian model. Different observers will order events differently in time if they move with different velocities relative to the observed events. In such a case, two events which are seen as occuring simultaneously by one observer may ,occur in a different sequence for another observer. All measurements involying space and time thus lose their absolute significance. Thus both space and time become merely elements of the language a particular observer uses for his description of the phenomena. An important. consequence of this notion occurs in relativistic dynamics when we consider the phenomena of motion. This is the realization that mass is nothing but a form of energy and the relation between the two is given by the famous equation $E = mc^2$. Thus, whenever one is describing physical phenomena involving velocities which approach c, the speed of light, relativistic equations of motion have to be used.

Special relativity theory was worked out by Einstein for 'inertial' frames of reference i.e. an unaccelerated system, a body that is acted by zero net external force and hence moves with a constant velocity. Einstein, in 1915 extended his principle of relativity to include non-inertial frames of reference as well. Pursuing the concept that one cannot distinguish experimentally between a gravitational field and an accelerated reference system, Einstein developed his general theory of relativity to include gravity. The force of gravity, according to Einstein's theory, has the effect of curving space and time, and in general the geometric properties of the space become non-euclidean. Thus whenever there is a massive object, ego a star or a planet, space around it is curved, and the curvature depending on the mass of the object. As space can never be separated from time in relativity theory, time as well is affected by presence of matter. Einstein's general theory of relativity thus abolishes the concepts of absolute space and time and the concept of empty space loses its meaning as the whole structure of space-time depends on the distribution of matter in the universe.

Another phenomena which shattered the concept of solid objects was the quantum theory. The phenomenon of radioactivity - the spontaneous emission of radiation by atoms - gave definite proof of the composite nature of atoms. An atom was thus found to consist of vast regions of space in which extremely small particles - the electrons - moved around the nucleus, qound to it by electric forces. An atom is extremely small compared to macroscopic objects (10 cm) but is huge compared to the nucleus in its centre. Quantum theory made it clear that even these particles were nothing like the solid objects of classical physics. The subatomic units of matter are very abstract entities which have a dual aspect. Depending on how we look at them, they appear sometimes as particules and sometimes as waves, like electromagnetic radiations. At the subatomic level, matter does not exist with certainty at definite places but rather show 'tendencies to occur'. These tendencies are expressed as probabilities and are called 'probability waves', which are mathematical quantities related to the probability of finding the particules at particular points in space and at particular times. A wave like in figure b tells the particule can be found anywhere along the wave with the same probability at anyone time. But a wavepacket like in figure c tells that particle is located somewhere inside the region X and has zero probability to be found outside. All the laws of atomic physics are expressed in terms of these probabilities. Thus, we can never preduct an atomic event with certainty; but only how likely it is to happen.



Quantum theory has thus destroyed the classical concepts of solid objects or basic building and blocks the deterministic laws of nature and has thus revealed a basic oneness of the universe. As we penetrate deeper Lnto matter, nature appears as a complicated web of·relations between the various parts of the whole.

In the 1930s, after quantum theory had unravelled the world of atoms, the main task was the structure of the nuclei, its constituents and the forces which hold them together so tightly. It was discovered the nucleus contained the protons and the neutrons, held together by the strong, extremely short range nuclear forces. Thus the electrons, protons and the neutrons wpich form the atbms were called 'elementary particles'. Later, many new elementary particles were discovered experimentally with improved techniques and over 200 are known today.

III EASTERN PHILOSOPHIES

Before drawing the parallels between modern physics and the eastern mysticism, a brief account of the eastern philosophy will be presented. The main aim of all these philosophies like Hinduism, Buddhism or Taoism is of course the direct mystical experience of reality.

More than for any other Easter tradition, for Hinduism the connection between philosophy and religion is particularly strong. Hinduism has great Ly influenced, India's social and cultural life particularly in the field of art and music. The manifestations of Hinduism range from highly intellectual philophies, involving conceptions of fabulous range and depth and profound insights to the naive ritual practices of the masses, who however keep the popular religion alive and colourful.

The spiritual source of Hinduism lies in the Vedas, composed at different periods probably between 1500 and 500 B.C. by various anonymous sages. The oldest parts contain sacred hymns and prayers. Subsequent parts deal with sacrificial rituals connected with the nedic hymns and the last part called the Upanishads elaborate on their philosophical and practical content. The Upanishads are not systematic treatises on philosophy but they contain essence of Hinduism's spiritual message. There is a directness about thier teachings, and authenticity born of first-hand experience in the highest reality of the mystic seers. They pour forth their findings in the form of stories and parables, informal discussions and intimate dialogues as in the story of Nachiketa in Kathopahishad or the large number of interesting stories in Chandogy Upanishad. Indeed, Upanishads (also called Vedanta) have been aptly described as the 'Himalayas of the Soul'. They have inspired India's greatest minds for the last twenty five centuries.

Teachings of Hinduism are also contained in the large number of popular tales and the epics like the Ramayana and Maha Bharatha and it is through these colourful tales that the ordinary people of India have learnt the teachings of Hinduism. Mahabharata Bhagavadgita clearly says that the battle of Arjuna is the spiritual battle of man, the battle of a warrior in search of enlightement. Krishna himself advises Arjuna[4] kill therefore with the sword of wisdom the doubt born of ignorance that lies in thy heart. Be one in self-harmony, in Yoga, and arise, great warrior, arise".

TEXTO 42

तस्मादज्ञानसंभूतं हृत्स्थं ज्ञानासिनात्मनः ।
छित्त्वैनं संशयं योगमातिष्ठोत्तिष्ठ भारत ॥४२॥

The basis of Krishna's spiritual instruction, as of all Hinduism is the idea that the multitude of things and events around us are but different manifestations of the same ultimate reality. This reality, called Brahman is the unifying concept in Hinduism in spite of the worship of numerous gods and goddesses. The word Brahman, from the root 'to grow' came to signify the ground of the universe or the source of all existence, that which has burst forth into the universe or that from which the universe has grown. It is infinite and beyond all concepts; it cannot be comprehended by the intellect, nor can it be adequately described by words. As is written in the Upanishads[5] 'Yet the Hindu sages

यत् तदद्रेश्यमग्राह्यमगोत्रमवर्ण-
मचक्षुःश्रोत्रं तदपाणिपादम् ।
नित्यं विभुं सर्वगतं सुसूक्ष्मं
तदव्ययं यद् भूतयोनिं परिपश्यन्ति धीराः ॥६॥

6. What is invisible, ungraspable, unoriginated
and attributeless; what has neither eyes,
nor ears, nor hands, nor feet; what is eternal,
all-pervading, immeasureably subtle and limitless
in manifestation; — that Imperishable
Being is what the wise perceive as the source
of all creation.

And in the words of Perialwar,
"Thou art light that never becomes extinct and is not
capable of being measured-." Periazhvar Tirumozhi
3-8-1

and poets have pictured Brahman as divine and talk about it in mythological language. The various aspects of the Divine have been given the names of various gods and goddesses worshipped by the Hindus but they are all but reflections of the one ultimate reality.

The manifestation of Brahman in the human soul is called Atman. And, the remarkable discovery which the upanishadic sages made was that the two are one and same: the Atman is Brahman[6]. Through the inquiry into the source of the universe and t hrougb the quest after the true self, the discovery was made that it is the one non-dual Reality that appears as the manifold world, according to Hindu mythology, is the divine play of God, the lila. Brahman transforms himself into the world and he performs this feat with his 'magic creative power'. Maya is the illusion of.taking the myriad forms of the divine lila for reality, without perceiving the unity of Brahman underlying all these forms. Maya therefore, does not mean that the world is an illusion but it is the illusion of taking man-made concepts of measuring and categorizing shapes and structures for reality, of confusing the map with the territory. To be free from the spell of maya means to realize that all the phenomena that we perceive with our senses are part of the same reality. It means to experience concretely and personally that everything including our own self is Brahman. This experience is moksha or liberation. This is the very essense of Hinduism. Hinduism holds that there are innumerable ways of liberation or moksha from maya, it therefore provides different concepts, rituals and exercises for different modes of awareness. One of the most popular ways of approaching the Divine is to worship it in the form of a personal god or a goddess. The three most worshipped divinities are Shiva, Vishnu and Shakthi.

In a similar way, in Buddhism also, the intellect is seen merely as a mean to clear the way for the direct mystical experience, called 'awakening' and thus to reach the world of 'achintya' the unthinkable where reality appears as undivided and undifferentiated 'suchness'. This was how it was experienced by Gauthama Buddha, the founder of Boudhism.

Like Hinduism and Buddhism, Taoism, one of the two main chineese trends of thought (the other being Confucianism) is mystically oriented and is basically a way of liberation from this world.

IV PARALLELS

As mentioned in the previous section the most important characteristic of the eastern world view is the 'awareness of unity and mutual interelation of all things and events, the experience of all phenomena in the world as manifestations of a basic oneness. The Eastern traditions constantly refer to this ultimate, indivisible reality which manifests itself in all things and of which all things are parts. This is Brahman in Hinduism, Dharmakaya in Budhism and Tao in Taoism.

The basic oneness of the universe is not only the central characteristic of the mystical experience, but it is also one of the most iroportant revelations of modern physics. It becomes apparent at the atomic level and manifests itself more and more as one penetrates deeper into matter, down into the realm of subatomic particles. The various models of subatomic physics express again and again in different ways the same insight that the constituents of matter and the basic phenomena involving them are all interconnected, interrelated and interdependent; that they cannot be understood or isolated entities, but only as integrated parts of the whole.

To see how quantum theory implies an essential interconnectedness of nature, Bohr and Heisenberg developed the so-called Copenhagen interpretation of quantum theory in the late 1920's. Basically, the physical world is divided into an observed system ('object') and an observing system. The object may be an atom, a subatomic particle, an atomic process etc. The observing system consists of the experimental apparatus and the human observer. The observed systems are described in quantum theory in terms of probabilities.

The position of a particle or how it reacts with another particle cannot be given with certainity. For example, most of the subatomic particles known today are unstable. It is not possible. however, to predict the time of decay of a particle or its mode of decay. One can only predict the odds that a particle will decay after a certain time or that it will decay in a particular way. This is a fundamental feature of the atomic reality and even the existence of matter. Such statistical predictions require several number of collisions to be recorded and analysed to determine the probability for a particular process. Similarity in an atom, the electron's position is represented by a probability pattern which is determined by the attractive force binding it to the nucleus and also by the forces exerted on it by other electrons in the atom.

Observation of a particle would then consist of creating the particle (call it process A) and then measuring its interaction or collisions with other particles (process B). Thus a particle is created and raised to a vpry high energy in a particle. accelerator (A) and then travels to the target area (b) which is usually a buble chamber where it collides with other particles and produces visible tracks to be photographed. In such an analysis, the particle constitutes an intermediate system connecting the processes at A and B. It exists and has meaning only in this context; not as an isolated entity, but as an interconnection between the processes of preparation and measurement. The properties of the particle cannot be defined independently of these processes. If the preparation or the measurement is modified, the properties of the particle will change too. Quantum theory thus reveals our essential interconnectedness. In the words of Neils Bohr, 'Isolated material particles are abstractions, their properties being definable and observable only through their interaction with other systems'

This, however, is the way in which the Eastern mystics have experienced the world as the following statements express:

"The material object becomes ... something different from what we now see, not a separate object on the background or in the environment of the rest of nature but .an indivisible part and even in a subtle wayan expression of the unity of all that we see[8]" .

"Things derive their mutual being and nature by mutual dependence and are nothing in themselves[9]".

The following statement by Heisenberg shows how close are the meanings conveyed by the Eastern philosophy and modern physics.

"The world thus appears as a complicated tissue of events in which connections of different kinds alternate or overlap or combine and thereby determine the texture of the whole".

Another crucial feature of atomic physics is that human observer is not only necessary to observe the collision processes but .is necessary even to define thier properties. They are only meaningful in the context of the object's interaction with the observer. The observer decides how to set up the measurement and this to some extent determines the properties of the observed particle. For example, when observing a typical particle iike an electron one may choose to measure its position and momentum. But according to Heisenberg's uncertainty principle, these two quantities can never be measured simultaneously with accuracy. The principle mathematically can be written as px = h where p is uncertainty in momentum of the particle, x its position on uncertainty- and the product of these two uncertainties is given by h, called Planck's constant (= 6.6×10^{-36} j.s.). This is a principle limitation which is inherent in the atomic reality and has nothing to do with the imperfection of the measuring techniques. Hence if an observer decides to determine the position of the particle fairly exactly, then there is a very large uncertainty in it's momentum value and vice versa. Thus, the observer becomes involved in the world he observes to the extent that he influences the properties of the objects observed.

This idea of participation of the observer is well known to every student of mysticism. Mystical knowledge can never be obtained just by observation, but only by full participation with onL s whole being. This notion in the Eastern world view goes to a point where observer and observed subject and object are not only inseparable but alsQ become inaistinguishable. Thus the Upanishads say[10]

"Where there is a duality as it were, there one sees another; there one smells another; there one tastes another ... But where everything has become just one's own self, then whereby and whom would one see? Then whereby and whom would the smell? Then whereby and whom would one taste?"

This then is the final apprehension of the unity off all things. It is reached accordirig to mystics in a state of consciousness where one's individuality dissolves into an undifferentiated oneness, where the world of the senses is transcended and the notion ot 'things' is left behind. Quantum theory has also aholished the notion of fundamentally separated objects and has introduced the concept of the participator to replace that of the observer.

When the eastern sages say that they experience all things and events as manifestations of i basic oneness, it does not mean that they deem all things to be equal. They recognize the individuality of things but..., at the sametime they are aware that all differences and contrasts are relative within an all embracing unity. Light and dark, winning and losing, good and evil, pleasure and pain, life and death are not absolute experiences belonging to different categories, but are merely two sides of the same reality; extreme points of a single whole. This point has been most extensively emphasized by the chineese sages in their symbolism pf yin and yang. They called the unity behind yin and yang as the Tao. The dynamic balance between the yin-female and yang - the male polarities is the principle aim of meditation and is often illustrated by Indian artists in the sculpture of god Shiva in the form of "ArdhaNariShwara' radiating serene tranquility.

The eastern seers affirm that such a union of one's male and female modes can only be experienced on a higher plane of consciousness where the realm of thought and language is transcended and all opposites appear as a dynamic unity.

The exploration of the subatomic world has also revealed a reality which repeatedly transcends language and reasoning. Unification of concepts which had until. now seemed opposite and irreconcilable turns out to be one of the startling features of this new reality. Particles are both destructible and indestructible; matter is both continuous and discontinuous and force and matter are but different aspects of the same phenomena. as we will see shortly.

As we have described before, matter has a dual aspect: it appears as waves and as particles. Which aspect it shows depends on the situation. In some situations the particle aspect is dominant in others the particles behave more like waves. Electrons are normally considered to be particles. yet when a beam of electrons is sent through a small slit it is diffracted just like a beam of light i.e. the picture on the photographic plate will contain bright lines separated by dark regions as would be expected in case of waves. Host of the electrons strike the film in the vicinity of the central maximum but a few strike further from the center near the edges of that maximum and also in the subsidiary maxima on both sides.

Interpreted in terms of particles. however this experiment poses very serious problems, First, although the electrons all have the same initial state of motion. they do not all follow the same path; in fact the trajectory of an individual electron cannot be predicted from knowledge of its initial state. The best we can do is to say that most of the electrons go to a certain region. fewer. to other regions and so on; hence give the 'probability' for an electron to stride each of the various parts of the film. This fundamental indeterminacy has no counterpart in Newtonian mechanics. where the motion of a particle or a system is always predictable if the initial position and motion are known with sufficient precision. This requires generalization of the kinematic language used to describe the position and motion of a particle. In making the needed generalizations one is guided by the classical theory of wave motion of mechanical waves like sound or water waves. Indeed such calculations were done by Erwin Schrodinger differential equation for a particle such as an electron in a hydrogen atom:

$$i\hbar \frac{\partial \psi(\vec{r},t)}{\partial t} = -\frac{\hbar^2}{2m} \frac{\partial^2 (\vec{r},t)}{\partial_x^2} + V(\vec{r},t)\ \psi(\vec{r},t)$$

The eigen functions $\psi(x,t)$ are solutions of this equation represent various possible states of the system and are also associated with energy levels of the system. Its general solution is of the form:

$$\psi(\vec{r},t) = \sum_E A_E(t_o) e^{-iE(t-t_o)/\hbar}\, U_E(\vec{r})$$

$$A_E(t_o) = \int \bar{U}_E(\vec{r}')\ \psi(\vec{r}',t_o) d\tau'$$

The meaning of such a wave function for a particle being that it describes the distribution of the particle in space. Hence it is related to the probability of finding the particle in each of the various regions; the particle is must likely to be found in regions where ψ is large and so on.

Thus the introduction of the probability waves, in a sense resolves the paradox of particles being waves. The wave pattern as a whole is a manifestation of the particle. Being a probability pattern, the particle has tendencies to exist in various places and thus manifests a strange kind of physical reality between existence and non existence. We cannot, therefore, describe the state of the particle, in terms of fixed opposite concepts. The particle is not present at a definite place, nor is it absent. It does not change its position, nor does it remain at rest. What changes is the probability pattern and thus the tendencies to exist in certain places. In the words of Robert Oppenheimer,

“If we ask, for instance, whether the position of the electron remains the same, we must say 'no'; if we ask whether the electron's position changes with time, we must say 'no'; if we ask whether the electron is at rest, we must say 'no'; if we ask whether it is in notion, we must say 'no''' [12]

These words seem to echo the words of the Upanishads[13].

ISAVASYOPANISAD

तदेजति तन्नैजति तद्दूरे तद्वन्तिके ।
तदन्तरस्य सर्वस्य तदु सर्वस्यास्य वाह्यतः ॥ ५ ॥

तत् That एजति moves ; तत् That न एजति moves not ; तत् That दूरे far ; तत् That उ अन्तिके near even ; तत् That अस्य सर्वस्य of all this अन्तः within ; तत् That उ again सर्वस्य अस्य of all this वाह्यतः outside.

It[1] moves, and it moves not. It[2] is far, and
It is near. It[3] is within all this, and it is also
outside all this.

1. [NOTES-1. It moves etc. In its real absolute state It moves not, i.e., is immutable; but in Its conditionedaspect It appears to be ever-changing, ever in motion.

2. It is far etc. — It is omnipresent. Or it can be explained thus: For the ignorant, It is far, i,e, very difficult to attain, but to the wise, It is very near because they know It as their very Self.

3. It is within etc. — It is immanent and also transcendent, i.e. beyond creation,beyond limitation. It has two aspects,the conditioned and the unconditioned. Hence the opposite epithets are given to It.]

Another reason why we cannot interpret the diffraction experiment in term of particles is due to Heinsenberg's uncertainty principle. There are fundamental uncertainties in both position and momentum of an individual particle and these two uncertainties, as we have explained before, are related inseparably. The two thus play complementary roles. The slit width represents the uncertainty in position of the electron, as it passes through the slit. The momentum uncertainty can be reduced only by increasing the slit width which increases the position uncertainty; and convensely, when we decrease the position uncertainty by narrowing the slit, diffraction pattern broadens and the corresponding momentum uncertainty increases.

The relation between the uncertainties of a particle's position and momentum is not the only form of the uncertainty principle. Similar relations hold between other quantities for example between the ttme an a[.omic event takes and the energy it involves. The relation is

$$\Delta E \,.\, \Delta t = \frac{h}{2\pi}$$

Thus a system that remains in a certain state for a very long time can have a very well-defined energy, but if it remains in that state for only a short time, the uncertainty in energy must be correspondingly greater.

Thus the subatomic world appears as a web of relations between the various parts of a unified whole. Neils Bohr has introduced the concept of complimentarity and says that particle picture and the wave picture are two complimentary descriptions of the same reality. Each is partly correct but each is needed to give a full description of the picture. This parallels closely with the Taoist notion of polar opposites and the profound harmony'between ancient Eastern wisdom and modern western science.

As said in a Tamil Pasuram,

"I do not exist without thee0 Narayana, nor dost you without me" .... Nanmukan Tiruvandadi[6].

Unification of seemingly separate entities also occurs when we talk about the concepts of space and time. These two concepts seemed entirely separate and different in classical mechanics but have been unified in relativistic physics by going to a higher dimension, the four-dimensional spacetime. Like the unity of opposites experienced by the mystics, it takes place on a higher plane i.e. on a higher dimension. This is where force and matter are unified; where matter can appear as discontinuous particles or as a continuous field.

To experience 'the unification of apparently separate concepts, one can even take the case of going from one to two dimensions, or from two to three. So the example of a circular motion and its projection on a screen, the opposite poles of the osciilation in one dimension (along a line) are unified in the circular movement in two dimensions (in one plane). Similarly, a transition from two to three dimensions can by a plane. In the two dimensions of that plane, the surfaces of the cut appear as two completely separate discs, but in the three-aimensions they are recognized as being parts of one and the same object. In the four dimensional case, however, one can no longer visualize the unity very well. It can only be experienced through the mathematical formalism of physicists theories.

Eastern mystics seem to be able to experience a higher-dimensional reality directly and concretely. In the state of deep-meditation, they can transcend the 3-dimensional world of everyday life and experience a totally different reality where all opposites are unified into an organic whole. When they try.to express this experience in words, they are faced with the same problems as a physicist in interpreting the relativistic theory. In the words of Lama Govinda, "An experience of higher dimensionality is achieved by integration of experiences of different centres and levels oJ consciousness. Hence the indescribability of certain experiences of meditation on the plane of three-dimensional consciousness and with in a system of logic which reduces the possibility of expression by' imposing further limits upon the process of thinking.[14] Thus Eastern philosophy unlike that of the Greeks has always maintained that space and time are constructs of the mind. The Eastern mystics treated them like all other intellectual concepts as relative, limited and illusory. Being able to go beyond the ordinary state through meditation, they have realized that the conventional notions of space and time are not the ultimate truth. These refined notions appear to be in many ways similar to modern physics as exemplified by relativity theory.

To further elaborate on the theory of relativity, Einstein recognized that temporal specifications are relative and depend on the observer. In everyday life, the impression taht we can arrange the events around us in a unique time sequence is created by the fact that C, the velocity of light is so high (3×10^8 m/s) compared to any other velocity that we experience, that we can assume we are observing events at the instant they are occuring. But when the observer moves with a high velocity with respect to the observed phenomena, the time span between the occurance of an event and its observation plays a crucial role in e~tablishing a sequence of events. Hence the importance of relative nature of simultaneity that whether or not two events at different space points are simultaneous depends on the state of motion of the observer. The time interval between them is in general different for two observers in relative motion. The quantitative relation between time intervals in different coordinate systems (or in different inertial systems) is given by

$$\Delta t = \frac{\Delta t'}{\sqrt{1-v^2/c^2}}$$

i.e. if a time interval $\Delta t'$ separates two events occuring at the same space point in a frame of reference S', moving with a velocity v with respect to a frame S, then the time interval Δt between these two events as observed in S is 'larger' than $\Delta t'$. Thus if the rate of a clock at rest in S' is measured by an observer in S, the rate measured in S is 'slower' than the rate observed in S'. This effect is time dilation. Similarly, there is relativity of length depending on the state of motion of the observer and this is given by

$$\ell = \ell' \sqrt{1 - v^2/c^2}$$

Which, says that the length of a ruler measured in S, in which the ruler is moving, is 'shorther' than in S' where it is at rest. Furthermore, according to relativity, no inertial frame of reference is preferred over any other 'in the formulation of physical laws. Each observer is correct in his own frame of reference'.

Thus, all measurements involving space and time lose their absolute significance and has forced physicists to abandon the classical concepts of an absolute space and an absolute time, as expressed by Mendel. Sachs in the following words:

"The real revolution that carne with Einstein's theory ... was the abandonment of the idea that space-time coordinate system has objective significance as a separate physical entity. Instead of this idea, relativity theory implies that the space and time coordinates are only the elements of a language that is used by an observer to describe his environment[16] .

In relativistic physics, a new situation arises because time is added to the three space coordinates (x,y,z) a~ a fourth dimensibn. The transformations between different frames of reference express each coordinate of one frame as a combination of the coordinates of the other frame, a space coordinate in one frame S will in general appear as a mixture of space and time coordinates in another frame (S'). Lorentz transformation equations for motion along the common X, X' axis are

$$X' = \frac{X - vt}{\sqrt{1 - v^2/c^2}}$$

$$Y' = Y$$

$$Z' = Z$$

$$t' = \frac{(t - vx/c^2)}{\sqrt{1 - v^2/c^2}}$$

Hence we have a four-dimensional continuum called space-time and this is the most characteristic feature of the relativistic framework. But, intuitively, we have no direct sensory experience of the 4-diffiensional space-time.

It makes no sense to ask which is the 'real' length of an object or what is the correct time interval between two observed events'. The length of a moving object is the projection of points in 3-dimensional space on to a 2-dimensional plane and its length will he different for different angles of projection. However, in the 'scattering' experiments of high-energy physics, spherical particles are reduced to 'pancake' shapes. Numerous experiments have confirmeq the fact that the lifetime of unstable particles can be about 7 times as long as their slow 'twin brothers' at 99% of the speed of light.

These ideas of space-time seem so akin to the wOkds of Aswaghosha:

"Be it clearly understood that space is nothing but a mode of particularisation and that it has no real existence of its own . . . Space exists only in relation to our particularising consciousness[17].

The awareness of an 'interpenetration of space and time' is repeatedly emphasized in Buddhistic sutra[18] and is seen as an essential characteristic of the enlightened state of mind. In the words of D.T. Suzuki:

"The significance of the Avatamsaka and its philosophy is unintelligible unless we once experience . . . a state of complete dissolution where there is no more distinction between mind and body, subject and object . . . We look around and perceive that . . . every object is related to every other object . . ."

In the 'general theory of relativity' the framework of the special theory is extended to include gravity[19].

Einstein formulated the "principle of gravitation equivalence, which became the starting point of the theory, that a non accelerating (inertial) reference frame S in which there is a uniform gravitational field and a uniformly accelerating frame S' with respect to S but in which there is no gravitational field are physically equivalent. The Einstein equations for gravitational theory are a set of non linear differential equations and have the form

$$R_{\mu\nu} = 0 \quad (\mu, \nu = 0,1,2,3)$$

Where

$$R_{\mu\nu} = \sum_{\rho=0}^{3} R_{\mu\rho\nu}$$

The solution of Eintein's equations that corresponds to the metric form in the neighbourhood of a spherically symmetric, time-independent gravitational charge centered at r = 0 is called Schwarzchild solution and is given by the Schwarzchild metric.

$$ds^2 = c^2 \left(1 - \frac{2GM}{rc^2}\right) dt^2 - \frac{dr^2}{\left(1 - \frac{2GM}{rc^2}\right)} - d\vec{r}_\perp \cdot d\vec{r}_\perp ,$$

where

$$d\vec{r} = (dr)\,\hat{r} + d\vec{r}_\perp$$

Einstein's principle of equivalence has been well confirmed in the experiments of the gravitational red shift on a pulse of radiation. The Doppler formula for the frequency received by a detector and the frequency emitted by an emitter in the two equivalent reference frames S and S' mentioned previously is given by

$$\frac{\nu'}{\nu} = \frac{1 + gd}{c^2}$$

and is found to be the same in both the reference frames Sand S'.

From this it is concluded that the whole structure'of space-time is extricably linked to the distribution of matter. Space is curved to different degrees and time flows at different rates in different parts of the universe. These are the results of Einstein's fields equations and observations in astrophysics which deal with extremely massive bodies have confirmed his theory.

Furthermore matter and empty space - the full and the void - were the two fundamentally different concepts of classical mechanics. In general relativity, these two concepts can no longer be separated. According ,to Einstein, matter cannot be separated from its field of gravity and the field of gravity cannot be separated from the curved space. Matter and space are thus seen to be inseparable parts of a single whole.

The Eastern sages too talk about an extension of their experience of the world in higher states of consciousness and they affirm that these states go beyond the ordinary awareness of space and time. They experience 'an infinite, timeless and yet dynamic' present. And, because such a dynamic reality defies all description and specification, it is often said to be formless; empty or void. But this emptiness is not to be taken for more nothingness. It is, on the contrary, the essence of all forms and the source of all life. Thus the Upanishads say[20]

अथ हाग्नयः समूदिरे तप्तो ब्रह्मचारी कुशलं नः पर्यचारीद्धन्तास्मै प्रब्रवामेति तस्मै होचुः प्राणो ब्रह्म कं ब्रह्म खं ब्रह्मेति ॥ ४ ॥

अथ ह Thereupon अग्नयः the fires समूदिरे said among themselves—तप्तः has undergone severe austerities ब्रह्मचारी (this) Brahmacārin कुशलम् properly नः us पर्यचारीत् (and) has tended, हन्त well, come अस्मै him प्रब्रवाम let us instruct इति. तस्मै to him ऊचुः ह (they then) said—प्राणः Prāṇa (life-breadth) ब्रह्म is Brahman कम् Ka (joy) ब्रह्म is Brahman खम् Kha (Ākāśa, ether) ब्रह्म is Brahman इति.

4. Thereupon the fires[1] said among themselves, 'This Brahmacārin has undergone severe austerities and has tended us properly; come let us instruct him.' They then said to him, 'prāṇa (life) is Brahman, Ka (joy) is Brahman, Kha (ether) is Brahman.'

[[1] The Gārhapatya, Anvāhāryapacana and Ahavanīya fires.]

The next important aspect that is brought forth both in Indian philosophy and modern physics is the dynamic nature of the universe. In the words of Dr. S. Radhakrishnan, 'the word Brahman means growth and is suggestive of life, motion and progress'. The Upanishads refer to Brahman as 'this unformed, immortal, moving, thus associating it with motion even though it transcends all forms. The order of nature was conceived by the Vedic seers, not as a static divine law, but as a dynamic principle which is inherent in the universe. This idea is also like the Chineese conception of Tao - the way' - as the way in which the universe works. Thus, Krishna says in Bhagavad gita, 'If r did not engage in action, these worlds would perish,[22]

TEXTO 24

उत्सीदेयुरिमे लोका न कुर्यां कर्म चेदहम् ।
संकरस्य च कर्ता स्यामुपहन्यामिमाः प्रजाः ॥२४॥

utsīdeyur ime lokā
na kuryāṁ karma ced aham
saṅkarasya ca kartā syām
upahanyām imāḥ prajāḥ

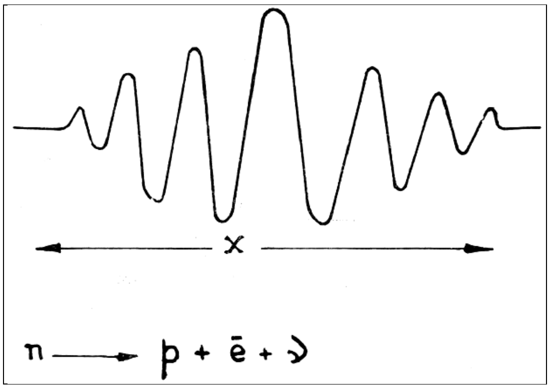
utsīdeyuḥ—arruinados; *ime*—todos estes; *lokāḥ*—mundos; *na*—não; *kuryām*—executa-se; *kārma*—deveres prescritos; *cet*—se; *aham*—Eu; *saṅkarasya*—de população indesejada; *ca*—e; *kartā*—criador; *syām*—seria; *upahanyām*—destruiria; *imāḥ*—todas estas; *prajāḥ*—entidades vivas.

TRADUCAO

Se Eu parasse de trabalhar, então todos estes mundos estariam arruinados. Eu também seria a causa da criação de população indesejada, e, por conseguinte, Eu destruiria a paz de todos os seres vivos.

In mythical Hinduism Shiva, the Cosmic Dancer is perhaps the most perfect and beautiful personification of the dynamic universe. Through his dance, Shiva sustains the manifold phenomena in the world, unifying all things by immersing trhem in his rhythm and making them participate in the dance - a magnificent image of the dynamic unity, of the universe.

Modern physics, too, has come to conceive of the universe as an inseparable intrinsically dynamic web ot relations. The dynamic aspect arises in quantum theory, as a consequence of the wave nature of subatomic particles. As we, have described, according to quantum theory, particles are also waves. Whenever, a subatomic particle is confined to a small region of space, it reacts to this confinement by moving around. The smaller the region of confinement, the faster with the particle move around. To see how this comes about, we have to remember that particles, in quantum theory, are represented by probability wave packets.



represents the uncertainty in the location of the particle. If we want to confine it to smaller region, we have to squeeze its wave packet into this region. This, however, will affect the wave length λ of the wave packet and consequently the velocity of the particle (from $\lambda = h/mv$). As a result, particle moves around faster.

The tendency of the particles to react to confinement with motion suggests a fundamental 'restlessness' of matter. Thus, in a world most of the material particles are bound to molecular, atomic and nuclear structures and therefore are not at rest but have an inherent tendency to move about. In the atoms, the electrons are bound to the atomic nuclei by electric forces which try to keep them as close as possible, and they respond to this confinement by whirling around extremely fast. In the nuclei, protons and neutrons are pressed into a minute volume by the strong nuclear forces and consequently race about with incredible velocities.

The dynamic nature of the universe, from physics point of view, is present not only when we go to small dimensions but also when we turn to large dimensions, i.e. to rhe world of stars and galaxies. Through the powerful telescopes it has been observed that the universe is in ceaseless motion, rotating-clouds of hydrogen gas forming stars and then to condense to form planets etc. In fact, some models of the universe describe an oscillating universe, expanding for billions of years, then contracting until its total mass has condensed into a small ball of matter, then expanding again and so on without end. This idea is to be found in Hindu mythology also where evolutionary cosmologies nave been described.

“The beginning of cosmic day Vishnu lies asleep, confortably cradled by Sesha - an enormous thousand-headed cobra and symbol of endless time. In turn Sesha lies curled on the primeval cosmic ocean. Vishnu has a lotus growing from his navel, which on unfolding its petals gives birth to the god Brahma creates the world, ready for Vishnu to govern when he awakes. Vishnu does this until the end of the day when he sleeps once more and absorbs the universe again into his body.

The day of Brahma lasts for 4,200 million earthly years. As we are in the 4th and final section of the current Day we may fast be approaching the reabsorption time but, have no fear, Vishnu has only lived through about 5,000 of the 432,000 years allotted to the final section of the day. There are 360 such Days in each Year of Brahma and 100 of these years form a complete Age of Brahma.

Hindu cosmologies are interesting in being the only ones that deal in such enormous, yet defined, lengths of time - in the 17th century Bishops Usher of Armagh fixed the Christian date of the creation at 4004 BC. And considering, how the entire created universe is believed to be re-absorbed into Vishnu’s body at the end of each Day of Brahma, it all begins to sound exactly like a description of a modern pulsating, ylem black hole cosmology.”

The Hindu myth of Lila is one in which Brapman transforms himself into the world. Lila is a rhythmic play which goes on in endless cycles, the pne becoming the many and the many returning to the One. Kalpa was the name given to the unimaginable time span between the beginning and end of one creation. In the Bhagavagita, Krishna describes this rhythmic play of creation as follows:

“At the end of then Lght of time all things return to my nature; and when the new day of time. begins I gring them again into light.

Thus through my nature I bring forth all creation and this rolls around in circles of the time.

But I am not bound by this vast work of creation. I am and I watch the drama of works.[23]

In relativity theory, this aspect of dynamic nature becomes clear. The discovery that mass is nothing but a form of energy has led to the realisation that particles are not 3-dimensional objects but 4-dimensional entities in spacetime; they are bundles of energy. Since energy is associated with activity with processes, the nature of subatomic particles is intrinsically dynamic. When subatomic particles collide with one another, particles can be destroyed and energy contained in their masses can be transformed into the kinetic energy of the other particles in the collision process. Conversely, when particles collide with very high velocities, their kinetic energy can be used to form the masses of new particles.

Thus in the dynamic, views of Eastern mysticism and of modern physics, then, there is no place for static shapes or for any material substance. The basic elements of the universe are dynamic patterns, 'constantly flowing and changing'.

What are the composite features of the various interactions between subatomic particles? These interactions involve a ceaseless flow of energy manifestating itself as the exchange of particles; a dynamic interplay in which particles are created and destroyed without end in a continual variation of energy patterns. Such a ceaseless cosmic dance of energy involves an enormous variety of patterns, hut they fall into a few distinct categories. Thys physicists, have found, a great deal of order in the study of subatomic particles and their interactions.

TEXTO 7

सर्वभूतानि कौन्तेय प्रकृतिं यान्ति मामिकाम् ।
कल्पक्षये पुनस्तानि कल्पादौ विसृजाम्यहम् ॥ ७॥

TEXTO 10

मयाध्यक्षेण प्रकृतिः सूयते सचराचरम् ।
हेतुनानेन कौन्तेय जगद्विपरिवर्तते ॥१०॥

All atoms and consequently all forms of matter in our environment, are composed of only three massive particles: the proton, the neutron and the electron. A photon is the name given to a unit of electromagnetic radiation and is massless. The proton, photon and the electron are stable particles but a neutron can disintegrate spontaneously in a beta-decay pror.ess as follows: $n \rightarrow p + \bar{e} + v$ where, a proton, an electron and neutrino are created. But this is only a fraction of the subatomic particles known today. All the others are unstable and decay again (in less than 10^{-6} sec) until a combination of stable particles is formed. The cost of such particles is very expensive as they have to be, created in collision processes and this involves huge particle accelerators, bubble chambers and other sophisticated devices. In most natural phenomena on earth, the energies are not high enough for massive particles to be created. However, in outer space, subatomic particles occur in large numvers in the center of the stars where collision processes similar to the ones in the laboratory occur all the time. In some stars, these processes produce strong e.m. radiation like radio, waves, light waves or, x-rays which is the astronomer's primary source of information about the universe.

Also 'mysterious cosmic radiation', the highly energetic radiation, hitting the earth's atmosphere contain not only photons but also massive particles of all kinds. When they collide with nuclei of atmosphere, they cause a great variety of particle patterns of creation and destruction.

All the particles fall into two broad groups: leptons (involved in weak interactions) and hadrons or strongly interacting particles. And all interactions following the laws of quantum theory fall into four categories varying in interaction strengths and ranges. They are the 1) strong interactions, like the nuclear forces 2) the electromagnetic interactions like between all charged particles 3) the weak interactions like between all charged particles 4) the weak interactions which are very weak and have a short range and 5) the gravitational interactions producing the force of gravity. In many of the collision processes, the strong, electromagnetic and weak interactions combine to produce an intricate sequence of events. The initial colliding particles are often destroyed and several new particles are created which either undergo further collisions or decay into stable particles which remain. A typical striking illustration of the creation of matter is when a massless but highly energetic photon, suddenly explosed into a pair of charged particles - an electron and a position - sweeping out in divergerrt curves. In another example an antiproton and a proton collide to create eight pions. An example of an extreme case is the creation of sixteen particles in a single collision between a pion and a proton.

As mentioned before, such a continual 'dance of creation and destruction' as has been called by some physicists, is parallel to the Hindu belief that all life is part of a great rhythmic process of creation and desctruction. In the words of Ananda Coomaraswamy:

"In the night of Brahman, Nature is inert, and cannot dance till Shiva wills it: the rises from his rapture, and dancing sends through inert matter pushing waves of awakening sound, and lo! matter also dances appearing as a glory round about Him. Dancing, He sustains its manifold phenomena. In the fulness of time, still dancing, He destroys all forms and names by fire and gives new rest. This is poetry, but nonetheless science". Indian artists of 10th Century have represented Shiva's cosmic dance in magnificent bronze sculptures of dancing figures with four arms expressing the rhythm and unity of life.

Thus, the metaphor of the cosmic dance thus unifies ancient mythology, religious art and modern physics.

So far, as this short history of modern physics tells us, the concept of 'basic building blocks' is no longer tenable, although it was extremely successful in explaining the physical world in terms of a few atoms; the structures of the atoms in terms of the nuclei surrounded by electrons and finally the structures of the nuclei in terms of protons and neutrons. Thus atoms, nuclei and hadrons were, in turn considered to be 'elementary particles' or the 'basic building blocks'. But each time these particles turned out to be composite structures themselves. Furthermore, the quantum theories of atomic and subatomic physics revealed a basic interconnection of matter, showing that energy of motion can be transformed into mass and suggesting that particles are processes rather than objects.

Still, the search for basic building blocks is going on. On the theoretical side of particle physics, the postulation of existence of elementary entities called quarks has gained support although there is persistent failure to, detect them experimentally the quark ffiodelhas been successful in accounting for the regularities found in the parmade of a small number of these quarks.

There is, however, a radically different school of thought in particle physics which starts from the idea that nature cannot be reduced to fundamental entities, such as elementary particles or fundamental fields. In this world view the universe is seen as a dynamic web of interrelated events. None of the properties of any part of this web is fundamental, they all follow from the properties of other parts, and the overall consistency of their mutual interrelation determines the structure of the entire web. This is known as "bootstrap' hypo-thesis developed by Geoffrey Chow[25]. Such a hypothesis not only denies the existence of fundamental constituents of matter but accepts no fundamental entities what so ever. Such a view comes even closer to the Eastern world view. An indivisible universe, in which all things and events are interrelated (and selfconsistent). No part of it is fundamental. The properties of any part are determined, not by some fundamental law, but by the properties of all other parts. In that sense, one might say that every part 'contains' all the others. Such a notion of 'all in each and each in all' is also to be found in Buddhism. The following metaphor in Hindu mythology in this context is even more striking.

In Indraloka, there is said to be a network of beads, so arranged that if you look at one you see all the others reflected in it. In the same way each object in the world is not merely itself but involves every other object and in fact is everything else. In every particle of dust, there are present Buddhas without number[26].

The foregoing discussion suggests that principal theories and models of modern physics lead to a world view which is internally conslstent and in perfect harmony with the views of Eastern philosophies. In everyday life, however, the mechanistic and the theories mystical views are valid and useful, the one for science and technology and the other for a balanced and fulfilled spiritual life. The world now arising from modern physics seems to be more fundamental than the mechanistic. Classical physics, which is based on the latter can be derived from quantum theory, which implies the former, whereas the reverse is not possible Thus science and mysticism are two complementary manifestations of the human mind, both necessary and imp,ortant for human beings.

CONCLUSION

The human curiosity to understand oneself has led to fundamental research beyond the realm of human sensory perception, into the microcosmos and the macrocosmos. The concepts of higher than three dimensiuns, relativity, duality of nature, interaction of the observer and the observed etc. not perceivable by the normal senses can only be expressed mathematically while ancient Hindu philosophers seem to have had a faculty to perceive the same through meditation. With the growth of solid state and computer technology the frontiers of hhman observations are being continuously extended. The new findings are often leading to more new questions. Perhaps, the mathematical concepts may seek the aid of our ancient philosophy even more in the future.

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Yoga-Vidya and Yoga-Vidhi

(The Science and Technology of Yoga)

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*"Taṁ durdarśam gūḍham anupraviṣṭaṁ
Guhāhitaṁ gahvareṣṭham puraṇam,
Adhyātma-Yogādhigamena Devam
Matvā dhīro harṣa-śoken jahāti."
Mrtyu-proktām Neciketo'tha labdhvā
Vidyam etām Yoae-Vidhiṁ ca kṛtsnam,
Brabmaprāpto virajo'bhūd vimṛtyur
Anyopy evam yo vid Adhyatmam eva.*

Yama, the experienced teacher, told Naciketas, the young seeker: 'The brave explorer real ses the Primal Light, difficult to be seen, extremely subtle, set in the cave of the heart, dwelling in the deep, through Adhyatma-Vidya and Yoga-Vidhi, and transcends both joy and sorrow.'

Having gained the whole of this knowledge of *Adhyatma-Vidya* and *Yoga-Vidhi*, as declared by Yama, Naciketas attained Brahman, the Supreme Reality, and was freed from both passion and death. And so may any other, who masters this knowledge pertaining to Man in Depth.

(*KAṬHA UPANIṢAD*, I.2.12 and II.3.18)

THE NATURE OF VIDYA

The Hindi word VIDYA and the English word SCIENCE are derived from the Sanskrit root vid and the Latin root scire, respectively, both roots having the same meaning, viz, ‘to know’. Thus, Vidya and Science refer to knowledge in general and without any limitation, although in the latter case there has been a deliberate trend in recent centuries to narrow down its scope to the so-called objective knowledge that can be verified by rational inference and laboratory experimentation. This modification in the scope of science has led to the division of knowledge into the physical and natural sciences with their technologies on the one hand and the religious and spiritual insights with their rituals and practices on the other. This artificial division has cost the human family dearly and resulted in many an avoidable conflict, personal as well as social, particularly in the European' and American countries where the most spectacular advances in the realm of physical and natural sciences were made in the last two centuries.

Needless to say, there is neither need nor justification to limit the scope of Vidya or Science in any manner. In fact, knowledge as such is one and indivisible. If at all any classification or grouping of different aspects of knowledge is called for, it can only be for the purpose of convenience in study and communication or else in the interest of specialization that is inevitable in view of the daunting vastness of the storehouse of knowledge and the tremendous rate at which codified knowledge is growing. As is generally well known, the reservoir of recorded knowledge doubled itself in about three hundred years, between 1600 and 1900 AD, and this doubling time has over the years reduced itself, first rather slowly and recently so unbelievably fast, that the present doubling time is between 10 and 15 years! However, such convenient classification of knowledge into different Vidyas or Sciences should not be allowed to degenerate into permanent water-tight compartments within the reservoir of knowledge, nor result in the emergency of any sort of antagonism or incompatibility between different spheres of knowledge, as has untortunatety happened in several parts of the world between the so-called modern physical and ancient spiritual sciences.

What characterizes Vidya or Science is not so much the content or quality of the knowledge acquired, asthe Approach to it. Vidya or Science has its temper and character, methodology and framework derived from buddhi or the pure intellect of Man, that is in no way polluted or corrupted, shackled or directed by manas or the lower mental faculty, which is the seat of feelings and emotions, prejudices and preconceived notions. It is the pure intellect that puts its indelible stamp on the manner or way in which the so-called scientific or rational knowledge is collected, codified and communicated. The search for such true knowledge will be characterized by an open and global, dispassionate and enquiring outlook and not suffer from any limitation or aberration imposed by prejudices, preconceived ideas or narrow affiliations of a cultural, national or ideological nature, all the latter constituting phenomena of the manas or the lower mental sphere.

YOGA TODAY

It is presently common knowledge that Yoga is among the oldest, most fascinating and most enduring cultural and spiritual traditions of humanity. A critical and unbiased study of the phenomenon of Yoga strongly suggests that the roots of this magnificent and many-splendoured tree with countless branches and myriad products go back at least to the Indus Valley civilization that flourished in the north-western part of the Indian sub-continent over 4 000 years ago. The numerous leavesand flowers, buds and fruits, all of many a hue and shape, brought forth by this unique and mighty tree have been attracting and captivating, nourishing and sustaining diverse types of seekers in every generation for over four millennia now.

The verbal foundations of the Yoga tradition obviously go back to at least 3 000 years. Surprisingly enough, even the oldest of these Yoga treatises, viz, the early Upanishads, particularly the Katha, the Svetasvatara and the Maitri Upanishads, the Yoga Sutras and the Bhagavad-Gita, all written in chaste Sanskrit, often in beatuiful poetry, and pre-Buddhistic in their thought content, deal with theoretical as well as practical aspects of Yoga on a fairly systematic. and, what one would like to stress today, broad scientific basis. All the same, there has been a great deal of hesitation and trepidation in India, the original home of Yoga, even after the attainment of Independence in 1947, to include Yoga as a subject for study in schools and universities and to develop it as a modern scientific and technological discipline of importance. This guarded and sometimes even apologetic approach to Yoga can be explained or understood only on the basis of the colonial hangover, where every thing indigenous became suspect and any thing from the prosperous and powerful West was welcome to our political leaders and social reformers, all generally educated in English and thereby indoctrinated in Western concepts and values. The times have, however, changed fast and Yoga is presently receiving considerable lip service from the leadership in all sectors of the Indian society and even a measure of concrete support from the country's State and Central governments. This delay in recognizing the importance and relevance of Yoga and even in starting a learned society at the national level to serve its cause has done considerable harm not only to Indians but to humanity at large. A resolute start in this regard a few decades earlier would have by now extended the obviously multifarious benefits of the science and technology of Yoga to countless millions of human beings who seek ways of attaining and maintaining sound physical and mental health, or look for relief from bodily and psycho-physical ailments, or wish to probe the ultimate heights of human capabilities, or long to pursue transcendental values like wisdom, illumination, enlightenment, beatitude, etc. The need for the benefits of Yoga seems to be more keenly felt than ever before in this world, as it is increasingly shaken and destablized by the stresses and strains of living in a fast-moving, cruelly competititve and highly impersonal environment moulded and maintained by the awesome advances of modern engineering and the concomitant human mania for material possessions, particularly machines and gadgets.

However, it is but appropriate to record here the valiant efforts of some individuals who did not fail to recognize the rightful place of Yoga in our Society and, despite the oppressive and alienating climate of the British Raj, rendered yeoman service to the cause of Yoga in the first half of this century. Many of them derived inspiration from the clarion calls of Swami J Vivekananda during the last decade of the nineteenth century to deal with Yoga 'like any other science', to realise that Yoga 'stands upon its own feet and in its own light', to rid the noble edifice of Yoga of the cobwebs of 'secrecy and superstition' and to guard against the anti-yogic activities of 'charlatans and cheats'. Special mention should be made in this connection of the great teachers of Yoga like Sri Aurobindo of Pondicherry, Swami Sivananda of Rishikesh, Swami Kavalayananda of Lonavla, Professor Krishnamacharya of Mysore and Sri Yogendraji of Bombay, who strove along with their many gifted disciples to interpret the theory and practice of Yoga to the outside world and to highlight its special relevance to humanity in this Age of Science and Technology. The last two are still happily with us, inspiring and enlightening many a votary of Yoga even today, despite their ripe old age.

Among educational institutions appreciative reference is in order here for the Banaras Hindu, Sagar, Venkateswara and Himachal Pradesh universities, which have given recognition to Yoga in recent years as an academic discipline and have been encouraging teaching as well as research in one or more aspects of Yoga. Some other institutions of higher learning, among them the prestigious Indian Institutes of Technology, have already organized instruction in yogic practices, particularly in Bahiranga (External) Yoga consisting of Āsana

(Body Postures), Praṇāyāma (Breathing Exercises) and Pratyāhāra (Sense Withdrawal Practices), for their students as a regular feature of their extra-curricular programme.

Not surprisingly, medical scientists in our country have also taken to research in the last three decades on ttie normal physiological and also neuro-physiological changes about by yogic practices of both the Bahiraṅga (External) and Antaraṅga (Internal) types, the latter comprising Dherene (Concentration), Dhyāna (Meditation) and Samādhi (Unitive Experience), the last three constituents of classical Ashtāṅga Yoga (Eight-Constituent Yoga). In this connection, special mention may be made of the research groups at the All India Institute of Medical Sciences, New Delhi, the Banaras Hindu University, Varanasi, the University of Madras, the National Institute of Mental Health and Neuro-Sciences, Bangalore and the Defence Institute of Physiology and Allied Sciences, Delhi. The names of medical pioneers like Dr B K Anand (Delhi), Dr K K Datey (Bombay), Dr K N Udupa (Varanasi), Dr B Ramamurti (Madras) and Dr T Desiraju (Bangalore) come naturally to one's mind in relation to these researches.

Following a strong and unanimous recommendation from the National Conference on 'Yoga, Science and Society' held at Varanasi in December 1979 under the auspices of the Centre for Yoga, Banaras Hindu University, the Indian Academy of Yoga came to be inaugurated at Varanasi on the eve of the Indian Science Congress early in January 1981. Although belated, the inauguration of a learned society at the national level to promote the cause of Yoga, its philosophy as well as practice, in all its varied aspects and from all points of view, viz, study and teaching, research and development, propagation and popularization' has rightly been hailed as a significant event in the long and fascinating history of Yoga. While embarking on the task of consolidating recent efforts in different parts of the country to recognize and develop Yoga as a modern scientific discipline, the Founder-Members of this Academy expressed their awareness of the many difficulties and complexities in their way. As they put it, the new Academy will 'proceed cautiously, step by step, to illumine with the torchlight of science all that seems dark, confusing and mysterious in our ancient tradition to the common, but earnest seeker'.

The developments referred to above are heartening to votaries of Yoga and definitely represent a new ferment in an age-old tradition. However, 'the woods are dark and deep' and we have 'miles to go' before the science and technology of Yoga can claim its due place in human society.

YOGA AS VIOYA AND VIDHI

The Katha Upanishad contains perhaps the first written word of man on Yoga, specifically and by name, although earlier portions of the Vedas do contain references to what we recognize today as yogic concepts and practices. What is of special interest to us here is that even this first text on Yoga recognizes, as is obvious from the two verses quoted at the beginning, the pure and applied aspects, the Vidya (Science) and the Vidhi (Practice or Technology), of Yoga. While the pure science is referred to as Adhyatma-Vidya (Science of Man in Depth), the applied science or technology is called simply Yoga-Vidhi (the Rules of Yogic Practice or the Technology of Integration or Unification). in this beautiful and popular Upanishad containing an account of the ennobling question-and-answer session between Naciketas, a young and determined seeker of Truth, and Yama, the gifted and experienced teacher who takes on only sincere and deserving students after dulv testing them.

As is well known, the Bhagavad-Gita, which consists of 700 sanskrit verses divided in 18 chapters, describes itself in the colophon at the end of each chapter as Brahma-yidya (Science of the Supreme Reality) and Yoga-Sastra (Treatise on Techniques of Integration and Unification), thereby highlighting the theoretical and applied aspects of the knowledge it conveys. This marvellous Sanskrit poem, 'which is second to none in its hold on the Indian seekers of Truth, is also a dialogue, in this case between Arjuna, an aristocratic intellectual and ardent seeker, and Krishna, described as Yogesvara (Supreme Master of the Science and Technology of Yoga). This inspiring conversation also is characterized by a genuine spirit of enquiry and a keen desire to know and understand on the part of the seeker, as one would expect today in any exchange between a student of Modern Science and his guide or teacher.

The age-old Yoga-Sutras of Patanjali consisting of 195 Stares (Aphorisms) were presented to the public under the title 'The Science of Yoga' some twenty years ago by Dr I K Taimni in the first-ever sizeable volume (over 400 pages) in the English language on this subject. This book has since proved popular and gone into several editions. Commenting on 'the tremendous amount of theoretical and practical knowledge' (that Patanjali has managed to incorporate in his 'very small treatise', Dr Taimni refers to Yoga as the 'Science of Sciences' in his scholarly work and adds:

‘This Science of sciences is too comprehensive in its nature and too profound in its doctrines to be fitted inte the framework of any particular philosophy-ancient or modern. It stands in its own right as a Science based upon the eternal laws of the higher life and does not require the support of any science or philosophical system to uphold its claims. Its truths are based on the experiences and experiments of an unbroken line of mystics, occultists, saints and sages, who have realized and borne witness to them through the ages.’

It seems quite obvious from the foregoing that, irrespective of the fact that the Upanishads, the Bhagavad-Gita and the Yoga-Sutras have traditionally been considered to belong to the domain of Indian philosophy and religion or oriental learning, these texts provide in fact a firm and adequate base for the development of a modern Science of Yoga, having both theoretical and practical aspects.

It is also relevant to note here that the sources of scientific or reliable knowledge were correctly recognized by the ancient masters of Yoga. Patanjali has the following to state unequivocally in the early part of his famous work:

"Pratyakṣānumānāgamāh Pramāṇāni

Direct Observation, Rational Inference and Verbal Cognition (or Recorded Testimony) constitute the sources of Right Knowledge." (1.7)

A modern scientist can accept the above statement without any reservation, although he will make an allowance for the considerable efflux of time and the consequent evolution in scientific thinking since Patanjali and insist on a broader interpretation of each source of knowledge. Thus, the use of apparatus and instruments to widen the scope of observation by the human senses, as exemplified by the construction and development of more and more sophisticated microscopes (to see smaller and still smaller objects) and telescopes (to see farther and still farther in the starry heavens), will be taken Into account to enlarge the scope of Pretvekshe, that is, direct observation or experience. In a similar way, the traditional associatIon of spiritual or rellolous texts with the word Āgama will now give way to an acceptance of all good scientific literature, whatever their language, source or discipline, under this head.

The Bhsqavad-Gita also stresses the importance of Buddhi (the pure intellect) in gathering right knowledge and thus encourages cultivation of the scientific spirit of enquiry on the part of the seeker. Its clarion call: 'Buddheu sereoem-envicche (Take refuge Iin your Intellect:- II. 49)' and its firm insistence on 'Peripreṡna (Enquiry or Dialogue-IV.34) as a prerequisite to higher knowledge also highlight the scientific basts of our ancient Yoga tradition.

Incidentally, Patanjali's Yoga Sutras, which constitute without doubt the first-ever comprehensive and crisp, systematic and straight forward treatise on Yoga, deal more with the applied or technological aspects of Yoga and less with its theoretical or purely scientific aspects. Where then is the theoretical basis for this primarily practical classic? It must be stated in answer that the Sāṁkhve-Derṡana (the insights of the Samkhya Philosophy), which is generally considered to be the oldest systematized philosophy of Indian Origin, does seem to provide the broad theoretical basis for the Yoga Sutras. although Samkhya and Yoga are traditionally dealt with as two different Dersenes (Philosophical systems) among the nine classical Dersenesoi our country. The evidence of the Bhagavad-Gita is overwhelmingly in favour of our considering Samkhya and Yoga as the predominantly theoretical and essentially practical sides respectively of the same Vidya or Science. The following famous half-verse of the Bhagavad-Gita clinches the issue for us:

"Ekam Sāmkhyam ca Yogam ca
yah paśyati sa paśyati.

He really sees correctly who views Samkhya and Yoga as one." (Y. 5)

THE UNIQUENESS OF YOGA

Every student of Yoga learns today that the word Yoga is derived from the Sanskrit root 'yuj' meaning 'to unite', 'to integrate' or 'to cohere', Thus, Yoga is generally taken to mean a 'state of union or integration or coherence'. The popular Indian view has been that Yoga refers to the union of the individual soul or consciousness with the cosmic, divine or supreme soul or consciousness and that this union constitutes the ultimate fulfilment of man. One may as well interpret the word as referring to the ultimate and most harmonious integration of all aspects or levels of the human personality or to the utmost or maximum coherence within oneself and with every thing in one's environment. Whatever the interpretation, we are here obviously concerned with a transcendental goal, an objective that goes beyond all normal human experiences, even beyond the intellect, as its scope and reaches are understood in Modern Science today, thus defying intellectual formulation of the nature of this goal in anv unique manner. However, this transcendental state can be reached, realized and experienced, bringing about profound changes at the physical, mental and intellectual levels-this is the testimony of many a votary of Yoga down the centuries, this is the assertion of many a yogic text, starting from the earliest, pre-Buddhistic ones. Thus, the uniqueness of the science and technology of Yoga starts with the very word 'Yoga' and all that it is supposed to stand for.

let us now look at the defInitions of the word Yoga in the three foundation texts referred to earlier:

"Yadā Pancȧvatiṣṭhente Jnānāni Manasa saha,

Buddhiś-ce na viceṣtati, Tam āhuh Paramām Gatim.
Tam Yogam-iti manyante sthirām-lndriya-dhāraṇām
Apramattas-tādā bhavati, Yogo-hi Prahhavāpyayau

The highest state is that, they say, when the five senses of knowledge, together with the Manas (the lower mental faculty) cease from their normal activities and the Buddhi (pure intellect) itself does not stir.

This, they consider to be Yoga, this firm holding back of the senses, when one is completely undistracted. Yoga, verily, is the beginning and the end.

Katha Upanisad, II.3.10 and 11

"Yogaś Citta-Vrtti-Nirodhaḥ.
Tadā Draṣtuḥ Svarūpe' Avasthānam.

Yoga is the state of Nirodha (cessation) of all Vrittis (fluctuations) in Citta (the mental being).

Then the Seer is established in his Sve-rupe (original or fundamental nature)."

(Yoga Sūtres, 1.2 and 3)

"Tam vidyād-Duḥkha-Samyoga-Viyogam Yoga-samjṅtam.
Yatro'paramate Cittam niruddham Yoga-Sevaya,
Yatra cei-ve Ātmanātmānam paśyann-Ātmani tusyati,
Sukham Ātyantikam yat-tad Buddhi-grāhyam Atindriyam,
Vetti yatra na caivāyam sthitas-calati Tattvataḥ,
Yam labdhvā cāparam Lābham manyate nadhikam tatab,
Yasmin sthito na Duḥkbena guraṇā-pi vicālyate.

Let this be known by the name of Yoga, this Viyoga, (disconnection) from Semyoqe (firm union) with Duhkha (sorrow or pain)-wherein the Citta (mental being) restrained by Yoga-Seva (yogic practices) comes to rest, wherein one beholds the Cosmic Self through his individual self and rejoices In the Cosmic Self, wherein one experiences that supreme bliss, perceived by the Buddhi (pure intellect), but beyond the reach of the senses wherein established one does not deviate from Truth, on gaining which one cannot conceive of any greater gain than that and wherein anchored one is not shaken even by the heaviest Duhkha (sorrow or pain)."

(Bhagavad-Gita, VI. 20-23)

It follows from the foregoing three definitions of Yoga emanating respectively from the three oldest texts of the Yoga tradition that the ultimate obiective of the theory and practice of Yoga has been recognized from the earliest times as the attainment of the highest level in consciousness or awareness, wherein the normal human cognition of pleasure and pain is transcended. Thus, apart from. matter and energy, the usual concern of modern science today, the new science of' Yoga will also have to deal with consciousness, that has until very recently been ignored by the Western scientists as a datum worthy of scientific investigation, The uniqueness and complex nature of the science and technology of Yoga will thus stem from this fact that it encompasses matter, energy, mind and consciousness in one stupendous sweep and as a colossal continuum underlying creation.

While the science of Yoga is thus concerned with the nature of the transcendental goal, viz, the Supreme or Cosmic or Divine Consciousness, the technology of Yoga will have to deal with the countless way-s, techniques, methods and practices, that lead the seeker from wherever he starts from to this ultimate goal. On the basis of all that has been stated earlier, the scope of Yoga can now be appropriately defined as consisting of the science of total man, or of man in depth or of human possibilities and the technology of conscious evolution or of personality development of self-unfoldment. This new science and technology will not only touch upon or overlap on diverse present-day areas of study, research and development, but will usher in a new kind of psychology that will transcend all cultural limitations and open out the farthest reaches of human nature.

TH E PROBLEM OF CONSCIOUSNESS

It has thus to be conceded that the study of consciousness received keen attention from the Indian Masters of Yoga over 4 000 years ago. They seem to have undertaken their studies and investigations in this regard in a scientific spirit with the object of arriving at the truth about Man and Nature. Significantly, after centuries of neglect the study of consciousness has been taken up in all earnestness in the West in recent years, not only by psychologists and psychiatrists, but also by physicists and biologists. Since the early seventies a spate of Conference Proceedings and a plethora of Monographs have been emerging from the citadels of modern physics and biology in the West on themes like states of consciousness, nature of human awareness, explorations in eastwest psychology, atomic physics and eastern mysticism, biological basis of religious, experience, psychology of relatedness, etc. Thus, ancient Yoga and modern science have already started rubbing shoulders in the international arena.

The importance of the study of consciousness has apparently been forced upon the modern world through the increasing recognition that the present serious crisis in human society can be resolved only through a change in consciousness and not through further technological changes in the outer physical world. This new mood of the West is effectively summed up by John White, Editor of 'The Highest State of Consciousness' (Anchor Books, New York, 1972) in his Introduction to this book:

"Political action, social work, this -ism, that -ology, are all incomplete futile actions unless accompanied by a new and elevated mode of awareness. The ultimate action, then, is no action at all except to change consciousness. In other words true revolution is revelation .

"In the years ahead, explorations of the self will be integrated and therefore interdisciplinary. They will bring together physicists, psychical researchers, psycho-physiologists, religious leaders and workera from other professions ....

"If the borders between self and environment can be made to disappear, this is likely to have profound effects on man's attitude to his environment, both social and physical. If the self is experienced as actually embracing other people, self-consciousness becomes social consciousness."

Such words of twentieth century scientists match in spirit, if not in letter, the profound sayings of the Upanishadic sages. One is reminded here particularly of the following two famous verses of the short and sweet Ise Upenised, among the oldest and most revered of Upanishads, composed over 3000 years ago:

"Yes-tu sarvāni Bhūtāni Ātmany-evānupaśyati,
Sarve-bhūteṣu cātmānaṁ tato na vijugupsate.
Yesmin-sarvāni Bhūtāny-Ātmaivābhūd-vijānataḥ,
Tatra ko Mohaḥ, kaḥ, Śokah, Ekatvam-anupaśyataḥ?

He who sees all beings in his own self and his own self in all beings, he does not feel any revulsion to any being. When all beings have, 'verily, become one with his own self, what delusion and what sorrow can there be to this Seer who has realized the fundamental Oneness?" (Iśa Upaniṣad, 6 and 7)

All the same, the consciousness aspect of Yoga, particularly in respect of the higher or expanded states of consciousness that are claimed to be achieved by Antaraṅga Yoga (Internal yogic practices involving meditation), constitutes the bigg est challenge to those who will take up the task of evolving and developing a modern science and technology of Yoga. Although science has been late in catching up with Yoga. the leap from art to science can be comfortably achieved In the coming years in regard to Bahiraṅga Yoga. (External. yogic practices involving psychophysical, breathing and sense-withdrawal.exercises) and the reported benefits therefrom in terms of the physical, psycho-physical and mental well-being of Man. The altered states of consciousness that are supposed to follow the attainment of Samādhi (Unitive Experience, also called Ecstasy, Trance or Total Absorption) through Dhyāna (Meditation on an Object) in the practice of Antaraiṅga Yoga and the profound impact of these on the body, mind and intellect of the practitioner are, however, yet to be subjected to detailed, systematic study as well as critical, experimental research. So difficult and complex and yet so exciting and important is this field of human consciousness, nothing less than a mighty and well-concerted international effort will be adequate for any quick and effective probe into this subtle and till now rather mysterious and ill-understood dimension of Man.

THE CONCEPT OF PRAJNA

The Yoga-Sutras state unequivocally that he practice of Dhāraṇā (Concentration) and then Dhyana (Meditation) on a chosen object leads eventually to Samādhi (Total Absorption or Unitive Experience), when a distinct and qualitative change in consciousness takes place all of a sudden in the practitioner and the latter enters into the realm of Prajiñā (Superconsciousness or Wisdom). The relevant Stares (Aphorisms) are the following:

"Trayam-ekatre Seṃyamah.
Taj-jayāt Prajńa-lokaḥ.

The three ((Dharana, Dhyana and Samadhi) together with respect to an object constitute Samyama (the great control). By mastering it (Samyama) the higher consciousness lights up (blazes forth)".

(Yoga-Sutras, III. 4 and 5)

It also follows indubitably from a study of other relevant Sutras of Patanjali that the word Samādhi covers a wide range of states of higher consciousness or superconsciousness and consequently Prajñā also stands for a wide range of levels of wisdom or enlightenment. There is considerable complexity and many a nuance associated with these different Samādhi and Prajñā states, but this is by no means surprising in view of their transcendental nature and the obvious difficulties in the way of their intellectual formulation. A distinct milestone in the long inner journey through this fascinating realm of superconsciousness is incidentally referred to by Patanjali as Rtambharā (Truthbearing) and as illumined by Adhvetme-Presede (Clarity of the man in depth or the spirit within, that is, The Spiritual Light) in his Sutras 1.48 and 47, respectively.

What happens actually when a person gets gradually stabilized in Prajñā after the initial, rather sudden Samādhi experience? Can one identify or characterize this person? In fact, such a question is actually raised by Arjuna in the, Bhagavad-Gita, viz.

"Sthitaprajñasya ka Bhaśa, Samādhisthasya, Kesava?
Sthitadhīḥ kiṁ prabhaṣeta, kim-āsits, vrajeta kim ?

What is the description of the man who is firmly stabilized in Prajñā, who is perpetually in Samādhi, O Krishna? How will this man of steady illumination speak, how will he sit and how will he move around ?"

(Bhagavad-Gia, II. 54)

These are difficult questions to answer at the purely intellectual level because of the higher dimension of all Prajna or Semsdhi experiences. But Krishna provides a comprehensive answer in over a dozen famous verses, hiqhliqhtinq particularly the changes in the Yogi, that are actually discernible to or felt by those around him. The qualitative or dimensional change, the so-called jump from one rung to the next higher one in the evolutionary ladder, is also beautifully brought out by Krishna in the following oft-quoted, but enigmatic verse:

"Yā Niśā sarve-Bhūtanām, tasyām jāgrati Saṁyamī,
Yasyām Jāgrati Bhūtāni, sā niśa paśyato Muneḥ

What is might for all beings is the state in which the Yogi (one who has mastered Samyama) is awake; what is the waking state for all beings is night for the Muni (the discerning sage}."

(Bhagavad-Gfta, II. 69)

Later the Buddha was to bring out the integral, all-comprehenstve vision of the Prājña (the person well settled in the higher level of consciousness or wisdom) in another significant Sanskrit verse, viz,

"Prajñā-Prasādam-aruhya, Aśocyah śocato Jañan,
Bhūmiṣtān-ive Śailasthah Sarvan Prājño-nupaśyati.

Having ascended the tower of Prajna and gone beyond sorrow, the discerning sage views his sorrowing fellow-men like a person on the mountain top those below."

This verse stresses the point that the Sage of steadfast illumination has himself transcended sorrow but is deeply concerned with the sorrows of his fellow-men. In fact, he lives for others only and his involvement in them is natural and spontaneous.

In his magnum opus 'The Life Divine', Sri Aurobindo, one of the greatest and most daring explorers of the Prajna-realm in this century, uses the word 'Supermind" to refer to the new faculty of the Gnostic being, the Yogi who has successfully made the evolutionary transition from the mental to the supramental state. As he explains it, normal mental nature and thought are based on a consciousness of the finite, but supramental nature is 'in its very grain a consciousness and power of the Infinite'. Hence arises all our difficulty in understanding and describing supramental nature. However, the following luminous passages from 'The Life Divine' (II.27) offer us a glimpse of the higher levels of superconsciousness:

"Our normal perception or imagination or formulation of things spiritual and things mundane is mental, but in the gnostic chang e the evolution crosses a line beyond which there is a supreme and radical reversal of consciousness and the standards and forms of mental cognition are no longer sufficient."

"Supramental Nature sees every thing from the standpoint of oneness and regards all things, even the greatest multiplicity and diversity, even what are to the mind the strongest contradictions, in the light of that oneness; its will, ideas, feelings, sense are made of the stuff of oneness, its actions proceed upon that basis. Mental Nature, on the contrary, thinks, sees, will, feels, senses with division as a starting point and has only a constructed understanding of unity."

"The gnostic individual would be the consummation of the spiritual man; his whole way of being; thinking, living, acting would be governed by the power of vast universal spirituality.......... In this consciousness he would live and act in an entire transcendent freedom, a complete joy of the spirit, an entire identity of the cosmic self and a spontaneous sympathy with all in the universe."

Thus, an intellectual formulation and appreciation of some thing beyond the intellect emerges, clear enough and compelling enough, starting from the Upanishadic sages meditating in the retreats of Himalayan forests of over 3 000 years ago and coming all the way down to a savant of the twentieth century trained far from the ancient home of Yoga, in modern British schools and colleges. It should now be an exhilarting task for the gradually emerging specialists in the new science of Yoga to grasp and to present it all to a world that is ready, nay is longing for it, in lucid language and scientific Idiom. No doubt, carefully conceived and meticulously executed researches on the human brain and the nervous system will eventually help versify many an empirical finding in the realm of consciousness.

YOGA AND SOCIETY

It is common knowledge today that millions of human beings in practically all countries of the world are attracted to the science of Yoga hoping for some relief, some gain, some inspiration of either a material or mental or spiritual nature. All these votaries of Yoga need to be helped with the right knowledge and the appropriate techniques to ensure them success in their quest for positive health or quick relief from suffering or rapid increase in efficiency in their worldly pursuits. But one should not overlook in the midst of this understandable preoccupation, which is nowadays profitable, if not positively lucrative, the main objective of Yoga, viz, illumination, enlightenment, super-consciousness, in short, transcendence.

It is here that the blessings of Yoga will eventually prove most useful to our troubled society; it is also here that we shall have the most fertile field for studies and researches that will widen the horizons and push the frontiers of the science and technology of Yoga.

Even the earliest texts on Yoga enumerate the many attractive gains of a physical or psycho-physical nature in case of those who practise Yoga regularly. Thus, the Śvetāśvatara Upenised declares:

"Laghutvam-Ārogyam-Alolupatvaṁ
Varṇaprasādam Svara-sauṣṭhavaṁ ca,
Gandhaś-śubho Mūtra-Puriṣam-alpaṁ
Yoga-pravṛttim prathamāṁ vadanti.

The first signs of advancement in Voga are lightness of body, good physical and mental health, noncovetousness, clearness of complexion, pleasing voice, agreeable body odour and scantiness of excretions."

(Śvetāśvatara Upenised, II.13)

Here one is first impressed with the powers of observation of our forefathers of over three millennia ago and also the scope for further fruitful modern scientific research on these lines with all sophisticated equipments now available. The drug and cosmetics industry may well take up cudgels one day agamst Yoga if age-old claims like the above are substantiated by modern science!

The reference to 'non-covetousness' in the verse quoted above suggests changes in qualities and attitudes, that may also be brought about by yogic practices, particularly of the antaraṅga (internal) type, involving meditation. The Bhagavad-Gita takes up in this regard where the above Upanishad has left off, as it were, and we have the followmg list of characteristics of special relevance to human society attributed to the perfected Yogi or Sthite-Prajña (Man of steadfast illumination or wisdom):

1. *Vīta-rāga-bhaya-krodhaḥ.*
   ..Beyond passion, fear and anger. (II. 56)

2. *Nirmamo-nirahamkāraḥ.*
   .. Devoid of possessiveness and egoism. (II.71)

3. *Sthira-buddhir-asammūḍhaḍ.*
   .. Firm in understanding and unbewildered. (V. 20)

4. *Sarva-bhūta-hite rataḥ.*
   ..Engaged in doing good to all living creatures. (V. 25)

5. *Maitraḥ karuṇa eva ca.*
   ..Friendly and compassionate to all. (XII.13)

6. *Anapekṣaḥ śucir-dakṣah.*
   ..Has no expectation, is pure and skilful in action. (XII. 16)

What a glorious prospect the foregoing descriptions offer to our feverish and care-worn world! The advanced Yogi not only finds fulfilment, he also becomes a great blessing to society through his many rare and desirable qualities, the like of which are unfortunately not instilled today either by higher education or by religious training. These fine qualities are natural to the Yogi's level of super-consciousness and there is no question of his having to cultivate them. To quote once again Sri Aurobindo's pregnant and powerful words which strongly echo the thought content of the-great Upanishads:

"The supramental being will have no need for any altruistic self-effacement, since this occupation will be intimate to his self-fulfilment, the fulfilment of the One in all, and there will be no contradiction or strife between his own good and the good of others....... His feeling of universality, his action of universality will be always a spontaneous state and natural movement, and automatic expression of the Truth, an act of the joy of the spirit's self-existence."

(The Life Divine, II,27)

EPILOGUE

So a brand-new and bright world beckons to us, a happy and harmonious world, illumined by a new brand of scientists, the Master-Scientists of Yoga. Over and above today's din and tumult caused by the trials and tribulations, trauma and torments of a tired and timid humanity, the dawn of a new age is gently, but ever so insistently heralded, the age of a new science and technology, the age of Samadhi and superconsciousness. The harbingers of this new era will be the emerging specialists of a new science, the proud inheritors of a precious legacy bequeathed to humanity by Indian sages over 4000 years ago. Let us invoke and welcome this world of tomorrow in the spirit that pervades the inspired poetry of Rabindranath Tagore in his immortal 'Gitanjali':

Where the mind is without fear and the level head
is held aloft, calm and clear;
Where knowledge is science and no rock of prejudice
halts its flow, free and fair;
Where the world is not broken up into fragments
by walls, national or parochial;
Where the swift stream of reason dries not on its way
in the hot sands of passion and hatred;
Where conscious evolution marches on with tireless steps
towards enduring wisdom and universal love;
Where words pellucid rise from the depth of truth
in choiceless awareness and Samadhi-bliss;
Where the intellect is inspired by unfailing Prajna
into newer horizons of thought and action;
Into that paradise on earth, votaries of science,
may our human family awake!

Challenges in Steel Industry

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INTRODUCTION

Delivering 18th Nidhu Bhusan Memorial Lecture gives me immense honour which members of the Institution of Engineers (I) sought to press upon me. I demurred being conscious of a sense of my inhibition to talk on a memorial lecture where my predecessors have covered wide ranging subjects starting from Yoga to Science and Philosophy. If or one would like to tread the path which is familiar to me. I had chosen in this lecture to dwell on the subject of "Challenges in steel industry". We are all connected with this industry in some way or the other. I have thought it proper to confine myself to the various aspects of iron and steel indus try and the challenge it poses to us.

We for one know that iron and steel industry has a long and respectable history. India is proud of her heritage on iron and steel making technology which dates back over 4000 years. In 415 AD, King Kumara Gupta set up the iron pillar of Delhi. The method of construction is thought to have been the welding together of iron discs and smoothing down the outer surface by hammering and filing. The pillar still stands today free from rust. It was steel ingots imported in Damascus from India which were forged into famous Damask sword blades. The presentation of 30 pounds of Indian steel to Alexandar by King Porus and the beams in Sun Temple at Konarak are the ancient marvels of Indian steel industry. As this development spread, gradually knowledge and methods grew, and so did the pace of development and the time came when the industry throve in the vortex of indus trialisation of the West and in some other nations.

One must therefore commendhighly the skills of our forbears who shaped the destiny of steel. We in India are greatly dependent on tradition and have high regard for time honoured techniques. With the change of time horizon tradition need to be integrated,with the modern-technique to reap the best result.

WORLD STEEL SCENE

The post war period has witnessed the spectacular increase in world stee1 production as shown in Fig 1. The, crude stee1 production which was 188 Mt in 1950 was increased to 717 Mt in 1980 with all time peak of 748 Mt in 1979. After the highest production in 1979 the worlds tee industry has been confronting a severe recession and the production has subsequently slumped to the level of 5.76 Mt in 1982.

The major share in the world steel output has so far been accounted for by the developed world as will be revealed from table 1; In spite of the fact that developing countries (exceeding 100 in number) have increased their percentage contribution from 2.1,%in 1950 to 14.4,% in 1981, the achievements made so far are far below the level sought by the. potentials, requirements and aspirations.

India, with a crude steel production of 10.7 Mt in 1981, contributed around 1.5% of world steel production and ranked 4th among the developing countries and 17th in the world. The trend of steel production in India since 1950 is presented in fig 2.

The world average per capita steel consumption in 1981 was 162 kg. But average cannot tell the whole story. Fig 3 demonstrates particularly high level of consumption within the four largest consuming countries - Japan, USSR, West Germany and the USA. Japan and the USA both reached their peak levels in per capitia consumption in 1973, Japan at 802 kg and the USA at 711 kg. India remained at the other end of the scale with 17 kg only, followed by other populated countries like Indonesia (14 kg), Pakistan (9 kg).

The extremely high growth rate of demand between the early 1960’s and early 1970's stimulated an exceptionally high rate of growth in capacity. And then came the oil crisis in late 1973 and world steel industry staggered under its impact. There was a sharp reduction in demand causing a fall in steel output by 16 per cent in 1975 (20 per cent in the USA and EEC). But by the time the changed market circumstances had been clearly recognised by the decision makers, many of the investment projects which commenced during the years 1970-74 were too deeply committed to be stopped. This resulted in increase in steelmaking capacity of the western World by further 10% by 1978. The inevitable result was a sharp fall in the capacity utilisation of the plant in spite of peak production in the next year (Fig 4). The. impact of oil crisis combined with the stringent pollution control laws imposed in the steel industries, necessiated massive investment in modernisation of the industry including investment measures to substitute oil with alternate fuel. Although not many additional capacities were added but the change over from conventional ingot casting to continuous casting added to the stee1 capacity. In Japan, where continuous casting replaced ingot casting in a massive way meant an additional marketable steel by about 10% due to higher yield of continuous casting process route.

Contrary to this, the developing countries have experienced a continued growth and their expansion of capacity by 50 per cent since 1974 is explained by two basic factors. First, apart from a temporary check in 1975-76, (due essentially to over-s bocking with imported steel ordered in the preceding boom years) consumption once again increased until 1980, stimulated by combination of high economic growth and high steel intensity. Secondly, the fact that domestic steel prpduction was less than half of total steel consumption in the developing countries in the mid 1970's gave considerable scope for local production to replace imports.

Investment for creating additional steelmaking capacity has been drastically cutdown in the face of sharp fall in world steel demand particularly in the developed countries.

However the investment in modernisation and providing pollution control facilities still continues.

Against this background let us see where our steel industry stands today.

INDIAN STEEL INDUSTRY — AN OVERVIEW

The real breakthrough in India's iron and steel industry took place when TISCO commissioned its first blast furnace in 1911 and rolled its first steel in 1912. Soon after the first world war, the increased demand of steel stimulated TISCO to undertake its expansion and diversification programme. Simultaneously IISCO and MISCO commissioned their units to produce their first pig iron in 1922 and 1923 respectively. During the late thirties and early forties these plants were modernised and many grades of alloy and special steels were developed including TISCROM, a high strength low alloy structural variety, used for the construction of Howrah bridge, the bullet proof armour quality steel etc. By the end of second world war, India’s finished steel production stood at 1.0 Mt/yr.

After independence the steel expans ion programme was under taken only in the mid fifties. Second Five Year plan envisaged increase in the capacity to 6.0 Mt ingot steel per year. Three steel plants each of capacity 1 Mt ingot steel per year were built at Rourkela, Bhilai and Durgapur under the Public Sector with the assistance from West Germany, USSBand UK respectively. These were designed, manufactured and supplied by these countries based on the technology prevailing in the fifties. However, LD converter process of steelmaking which was at thestage of infancy, was adopted at Rourkela in the mid 1950’s. Rourkela was then the third plant in the world based on this process. This was a bold step which has later proved to be a step in right direction.

TISCO and IISCO plants were expanded to 2.0 Mt and 1.0 Mt of ingot stee1 per year respectively during the same period.

To meet the growing steel demand, the first phase of expansion of Public sector plants were undertaken; Rourkela to 1.8 Mt, Bhilai to 2.5 Mt and Durgapur to 1.6 Mt/yr (during the Third Plan period 1961-66). The expansion of these steel plants basically utilised the in-built capacity.of primary and intermediate rolling mills, and by and large the technologies remained the same as already adopted at the million tonne stage.

To sustain the growth of engineering industries, new capacity was created for production of alloy and special steel by setting up an Alloy Steels Plant at Durgapur and expansion of MISL with production capacity of 100,000 t/yr each. In addition, a number of alloy and special steel plants were set up in the private sector.

As a result of large gap between the domestic demand and availability of mild steel during late sixties and early is eventies there was mushroom, growth of mini steel plants during this period.

Another steel plant at Bokaro with an initial capacity of 1.7 Mt/yr was commissioned during the Fifth Five Year Plan period.

The second phase expansion of Bhilai from 2.5 to 4.0 Mt and Bokaro from 1.7 Mt to 4.0 Mt is under implementation and likely to be completed by 1984.

With the completion of Bhilai and Bokaro’s present expansiont the total crude steel making capacity will stand at 18.2 Mt/yr including 3.8 Mt/yr contribution from the Electric Arc Furnace units (capable to produce all type of steels) required for overall industrial growth of the nation.

But the world steel industry including our own are faced with serious challenges — challenges of continued low demand and prodiuction. Our own steel industry, besides faced with lower internal demand are beset with problems of raw materials, energy, challenges of modernisation and capacity expansion in an environment of shortages of adequate funds. And then the challenges of research and development for new process and products, challenges for technological self reliance for plant equipment and systems development.

During its long and chequered history world steel industry have faced many such challenges and it has been able to successfully overcome in the past. Can our steel industry meet these challenges and come out successfully? Let us examine these challenges one by one.

MARKET

One of the major challenge which the steel industry faces today is in the market front. The main steel market for the principal product groups are shown below:

Steel Products	Main markets in order of importance
Sheet, coil & strip	Motor vehicles, electrical & other machinery, holloware & other household equipment
Bars & sections	Construction, non-electrical machinery, mining, oil & gas extraction
Tubes & fittings	Construction, non-electrical machinery, oil & gas extraction
Plates	Machinery, construction, shipbuilding
Wire rods	Wire & wire products (including fasteners)
Tinplate	Containers
Special steels	Machinery, motor vehicles, aircraft
Semi-finished steel	Drop forgings for motor vehicles
Rails	Railways, mining

Three consuming sectors which account for at least 50% of the market are:

— automobile industry (sheet, coil and strip, bars special steels)
— construction (section, plates, tubes)
— machinery including electrical (sections, plates, sheets, tubes)

As a general rule, the more developed is the market economy, greater is the countries emphasis on automobile industry and hence of sheet and coil. In a developing country on the other hand the construction industry is usually of primary importance. Elsewhere, construction and machinery have tended to loose importanee because of slower economic growth.

The investment on equipment manufacturing sector, in general, has, decreased making steel demand sluggish after 1974. The world-wide surplus of ships caused steel demand in the ship building field also to decline. Another factor that contributed to the less steel demand is the gradual fall in consumption of steel per unit of manufactured goods, mainly because of improvement in design and use of stronger therefore, lighter steel. A decline of about 0.5% in steel intensity per year is normally due to technological changes. In recent times materials like plastics, aluminium and ceramics have also taken away some share of steel from the manufacturing and construction sector.

The main share of stee1 demand, in a developing country like ours, comes from construction and building sectors.

Steel being a basic metal, its production does not serve a meaningful purpose unless an absorption capacity is created in the downstream sectors to consume the same, which in turn involves capital investment. This simply reveals that a long term steel plan necessarily entails formulation of national perspectives for inter-industry growth. It may be appropriate to mention here that while about 80% of the Indian population is concentrated in the rural areas, the share of primary sector in GDP is as high as around 38%. As such, to have a balanced economic development, higher steel consumption in the rural areas h8s to be emphasised while planning for the inter sector growth.

RAW MATERIALS

Raw materials constitute a key factor in the development of steel industry. One tonne of steel requires conversion of approximaterly 3-4 t of raw materials comprising iron ore, metallurgical coal, limestone, ferro alloys, etc. Iron ore and metallurgical coal constitute bulk of the raw materials.

Iron ore

In India we are quite favourable placed with respect to availability of iron ure and its Fe content as can be seen from table-2. However, the problem with our ore is twofold, high alumina content and relatively soft nature of the ore.

Besides, there are continuous deterioration and fluctuations of chemical composition of ore in the mines which are adversely affecting the blast furnace operation and productivity.

World reserves of iron ore — Table 2

(Unit: million tonne)

Country	Iron ore	Recoverable iron	Implied grade (%Fe)
U S A	25,401	5,263	20.7
Canada	26,417	8,348	31.6
Australia	17,781	10,708	60.2
Brazil	34,546	19,601	56.7
Venezuela	2,337	1,270	54.4
Liberia	1,668	660	39.5
South Africa	6,300	3,721	59.1
France	4,068	1,633	40.2
Sweden	3,353	1,996	59.5
India	13,500	8,306	61.5
Rep of China	42,000	12,600	30.0
U S S R	110,750	28,131	25.4
Others	2,235	635	28.4
	290,352	102,872	(average) 35.4

High aluminous ore increases the viscosity of BF slag. To counteract this, silica rich minerals are to be added to make the slag fluid resulting in decrease in BF productivity, increase in coke rate and high silicon in the hot metal. This tends to increase the cost of production of hot metal and steel. We have to find solution to this basic problem. For attaining low ratio of alumina to iron in the iron ore, conventional method of iron ore beneficiation viz washing and wet screening with or without scrubbing, have been tried but not found to be effective in preferential removal of alumina. Research and Development work is in hand for preferential removal of aiumina during washing of iron ore with the help of polymer addition. Research work is also being carried out for beneficiation of iron ore fines by flocculation.

Due- to the relatively soft nature of our iron ore and large scale mechanisation of mining operation, huge quantity of fines are generated, during mining (as high as 70%). These fines need agglomeration through a process of sintering and/or pelletisation prior too feeding into BF. Generally sintering process does not accept large quantities of ultra fines. However, certain propqrtion of ultra fines can be ultilised during sintering with modification of technology like preballing of sinter-mix, lime addittions, etc.

The constraint of high fluctuation in quality of iron ore supplies from the mines can be overcome by providing elaborate averaging and blending facilities which will ensure consistency in quality of input to production units.

Coal

The total world reserve of metallurgical, and non-metallurgical coals in measured, indicated and inferred categories of solid fuel amount to about 10, 000 billion tonne. About 500 billion tonne of this is economically recoverable using known mining technology.

Current recoverable reserve of metallurgical coal in the world is estimated around 50,000 mt.

With the present consumption rate of 600 Mt/yr of metallurgical coal this would last for about 80 years, not as long as the ore supplies, but ample time to develop new mining techniques, discover new resources and develop new carbonisation processes. Added to the above, metallurgical coal is unevenly distributed in the world. Only a few countries control major production of metallurgical coal. Majority of the developing countries have very little reserve of metallurgical coal.

India is not so fortunate with respect to its reserves of metallurgical coal as of iron ore. The details of the coal reserves in India are given in table 3.

Table 3

Indian Coal reserves

(Unit: million tonne)

Sl No	Description	Proved	Indicated	Inferred	Total
1.	Prime coking	3,653	1,237	359	5,250
2.	Medium coking	3,849	4,275	1,252	9,376
3.	Semi or weakly coking	1,554	2,453	715	4,722
4.	Non coking coal	12,291	22,864	28,197	63,350
	Total	21,347	30,829	30,523	82,698

It can be seen that Indian coal reserves constitute a meagre 0.8% of the total world coal reserves. The coking coals reserve amounting to about 19 billion tonnes are available mostly in the Damodar Valley area of Bengal-Bihar region and constitute around 25% of the country's total reserves. The reserve of prime coking coal is limited and hence there isa need to conserve it.

Besides limited reserve, Indian prime coking coal has high ash content, around 28% as against 8-10% in other countries and in some countries around 4%. The ash in Indian coal remains at a high level even after washing. The ash content of coal blend which used to be 17 -18% in the 1960's has now gone up to the level of 22-23%. As we are goang deeper and deeper in mines the coal qualities are deteriorating.

This high ash in our coal is proving to be very critical for blast furnace operation for iron making. The coke produced from indigenous coal blend is not only resulting in higher ash content but also of poor strength (with M_{10} value indices caryingbetween 10-15). Apart from loss of blast furnace productivity, increase in coke rate, inconsistent quality of hot metal, etc this is also threatening the smoother operation of the furnaces.

Our steel industry is thus faced with another major, challengs of coal quality which is bringing down our blast furnace productivity and adding to our cost of production.

Recently, we have resorted to import of coal in a limited scale but this has not helped to reduce the cost of production as the productivity increase is not commensurate with high cost of imported coa1. But then it has helped to tide over the problem of shortages as well as helped in imprpving the technological and operational parameters of blast furnaces to a certain degree.

The long term solution to this major and basic problem has, to be found out.

Intensive research work has to pe undertaken to develop economically viable methods for beneficiation of coal. At, the same time laboratory as well as pilot scale investigation are to be carried out to arrive at the optimum coal blend to attain adequate strength of the coke suitable for efficient blast furnace operation. The techniques aimed at substitution of metallurgical coal with weakly/non coking coal and improvement in coke strength have to be developed and adopted for carbonisation of coal.

Other Raw Materials

Besides the iron ore and cool the other raw materials flUxes like limestone, dolomite, etc.

Normally, our steel plants use calcined lime containing about 80% CaO and 6-10% SiO_2 as compared to 95% CaO and 1% SiO_2 used by European Steel plants. Higher silica means higher slag volume and lower furnace productivity with associated economic disadvantages.

Besides the above, there are other raw materials, not directly used in the metallurgical process but are needed for manufacture of consumables like bricks. Bricks of different qualities like silica, fire clay, tardolomite, are used in large quantities in different units of steel plant.

Worthmentioning, here is the converter lining bricks (BOF converter) used in Indian steel, plants. Lining life of basic oxygen furnaces in Indian; steel plants is only 150-200 heats because of inferior quality of dolomite as against a lining life of 2000-3000 heats, in Japan. The use of magnesite bricks to be produced from sea water magnesia will give much better life than tar bonded dolomite bricks being used at present. Efforts have to be made to find permanent and cost effective solution to this major problem.

ENERGY

The iron and steel industry is the major consumer of energy. Energy consumption in the steel industry is about 15% in Japan, 9% in West Germany, 7-8% in France and 4,% in the USA of their total domestic consumption. The two energy crises, one in 1973 followed by another in 1979 have compelled the steel industry too use energy in most judicious manner and to save energy wherever possible in different processes. Compared to the price hike for liquid fuel and natural gas there has been only moderate increase in the price of coal in the recent past. This has led to developments aimed at diversification of useable energy sources such as non-coking coal, charcoal, etc. The energy accounts for more than 20% of the cost of steel at present time. With the increase in price of energy sources, the cost of production of steel is bound to go up.

Figure 5 shows the current utilisation pattern and the distribution of losses of energy in a steel plant. The specific energy consumption per tonne of saleable steel has been gradually brought down to a level of 5-7 Gcal/t in the industrially developed countries as a result of all out efforts to reduce the energy consumption as indicated in Figure 6. In our steel plants on the other hand we are operating at a level or 9-16 Gcal/t as indicated in Figure 7. This has posed a serious challenge to our steel plant as to how to bring down the specific energy consumption.

The Japanese steel industry has done a remarkable job in this direction. Just before the first oil crisis the Japanese steel industry stood with a consumption figure of around 6.2 Gcal/t after bringing down the same from 9.6 Gcal/t in 1960 by decreasing BF fuel rate (46%), improving the open hearth heat efficiency (18%), shifting from OH process to Oxygen steel making process (15%) and energy saving measures in other areas (21%). Soon after the first energy crisis, the consumption was further brought down by 10% in course of less than 6 years by measures indicated in Fig 8.

Continuous cas ting of stee1 is a great energy saver. Each one percent increase in continuous casting under Japanese condition recoups energy between 1,000 - 1,500 Kcal/t of steel produced. As a major step forward in the energy conservation drive in Japan, this technology was adopted, increasing the continuous, casting ratio from meagre 11% in 1970 to more than 82% today, just in a span of 12 years.

The Japanese have gone further from there, adoping direct rolling and, hot charging of continuously cast slabs which is another important link in the energy saving chain. Today more than 50% of HR coils produced in Japan is directly, rolled from continously cast slabs. Hot charging technique saves about 50,000 Kcal of energy for each tonne of semi finished steel.

Another important strategy of ‘save energy campaign’ hinges on the recovery and use of what would otherwise be wasted. This covers a very wide area, right from coke dry quenching, sinter waste heat recovery, BF top pressure recovery turbines, hot stove waste heat recovery, BOF gas energy recovery, waste gas boiler at reheating furnaces, skid evaporation cooling at reheating furnances, banking of heat radiated from hot slabs at the roller tables and the recovery of sensible heat from finished products as well as slag as they cool. Presently about two billion kWh or about 5% of the total power consumed by Japanese steel industry is generated by waste heat recovery systems and converting the same into electric power.

The scope of energy reduction for Indian steel plants is enormous; right from phasing out of obsolete energy intensive processes and equipment to adoption of new technological innovations which have already been established in developed countries. But the most important energy saving drive will be towards inexpensive and ingenious changes in operating and maintenance practices.

TECHNOLOGY

The greatest challenge that the steel industry faces today is how to reduce the cost in the face of the rising prices of inputs. like raw materials, energy, and labour and at the same time to meet the demand of high quality steel products that would provide higher strength for same weight ratio, improved corrosion resistance, better performance at sub-zero temperature, high pressure and temperature applications, etc. It is confronted with conflicting requirements as to product quality on the one hand emphasising the continua1 quality improvement while on the other hand giving priority to cost over quality to meet the threat from other competitive light materials to keep its market share.

How do we meet these challenges? The task is enormous before the Indian steel industry. While we seek to find solutions in each individual area of challenge the steel industry is facing, these are all interlinked and no solutions will be effective unless all linkage ramifications are examined. This then brings us to another area and before we go over to the answers to these challenges, let us examine the new process and new technologies which are in the horizon.

In the new process front, direct reduction process is considered one or the rare and radical technical advancement of the seventies. Steel Plant projects based on direct reduction process have multiplied. The real breakthrough of direct reduction process has been in those developing countries which are endowed with oil and natural gas. Though majority of the project are based on the use of natural gas/associated petroleum gas as reducing agent, the processes based on non-coking coal are finding favour in countries with adequate reserves of non-coking coa1 and iron ore like Indla, South Africa, Peru, etc.

A large nurnber of processes (a mong them smelting reduction process) using non-coking coa1 are at various stages of development. Some of the promising ones are

- KR process (Kohl Reduction process), West Germany/Austria
- INRED process (Intensive reduction process), Sweden
- EIRED process (Electric reduction process), Sweden
- Plasmared process, Sweden
- COMBISMENT process, West Germany
- INMETCO process, USA
- KRUPP COIN process, West Germany
- MC dowel-Wel1men process, USA
- KAWASKI STEEL process, Japan
- Sumitomo process, Japan
- FERROCAL PROCESS, USA

Developments in this direction are being watched carefully by the whole steel world particularly developing countries not possessing good reserve of metallurgical coal like India.

R&D efforts are continuing to develop other radical new processes. Some of these processes and their evaluation by, the office of Technology Assessment, IISI is given below.

Radically new process	Possible transition to a significant industrial state		
	1985	1990	2000
Production of steel using plasma arc			?
Direct steelmaking		?	?
Continuous steel production		?	?
Hydrometallurgical production of cast iron		?	X
Steel production using nuclear energy			?
Various systems using hydrogen		?	X
Top casting of steel		?	X
Coke substitute (formed coke)		?	X
Direct fabrication of rolled products from powder ?			

(X Attainment of commercial status, ? Doubtful)

It is worth mentioning here the conclusion which emerged from the discussion at Amsterdam conference devoted to “Changes in iron and steel technology” held in September, 1979.

“It is inconceivable that a radical new process capable of replacing the standard coking plant - BF-Oxygen converter-continuous casting route could emerge within the next ten years”. There has been a general agreement among the leading steel technologists that the predominance of the above process route supplemented by electric arc furnace route would continue during the eighties. Within the frame work of the main process route mentioned above, modernisation of plant and equipment and intensification of process incorporating multiple technological innovations will be carried out in years to come.

While we shall continue to remain alive with our interest relating to the new processes these are not likely, to replace our major steel making route which will continue to remain as Blast Furnace — BOF steel making for quite sometime. Let us therefore, examine the challenges in different areas.

Ironmaking

The technological development of blast furnace process over the past 20 years, incorporate intensification of the process by higher top pressure, auxiliary fuel injection, oxygen enrichment of the blast, coupled with improved burden preparation and increased hearth diameter. These developments have led to significant increase in the furnace productivity (as high as 2-2.5 t/m^3/day) and marked decrease in fuel rate (as low as 430 kg/t of hot metal). Side by side, development has also taken place in the field of equipment and system design notably conveyorisation of charging system, more effective burden distribution system (Paul wurth/adjustable throat a~mour), improved cooling system of stack and hearth, use of better quality refractory particularly in the hot blast line, mechanisation of cast house operation, etc. These are marked by improved availability of the furnace along with consistancy of its operation.

To meet the challenges of our raw materials and their deteriorating conditions, preparation of raw materials, increase in sinter content of the burden, sizing of the burden, minimising the fines content in the burden, improved charging system in blast furnace, improvement in quality of coke with respect to its strength and ash, pulverised coal injection through tuyeres are considered to be the immediate need of our blast furnaces. To improve the strength of blast furnace coke as well as to enable partial substitution of prime coking coal by weakly/non-coking coal, processes like selective crushing, preheating of coal charge, stamp charging, partial briquette coal charge (PBCC), etc need careful consideration for adoption in our plants.

Steelmaking

The most important development in oxygen steel-makfng is that of combined top and bottom blowing of the liquid iron in the converter vassel. The mixed blowing approach usually takes the form of oxygen blowing from the top, coupled with bottom blowing of inert gas (Argon, Nitrogen), used solely, or in conjunction with various combinations of O_2, CO_2, C_3H_8, etc. These measures improve yield, productivity, quality, composition control, oxygen efficiency, alloying element recovery and increased use or scrap. Combined blowing practices are replacingthe conventional pure oxygen top blowing method in a big way.

A major development of the past decade has been the production of clean steels through the application of ladle or secondary refining techniques in an effort to improve mechanical properties with reduced. I sulphur and oxygen contents and modification of the remaining sulphur into globular non-deformable sulphide i.e. sulphide shape control.

The steel makers allover the world are producing ever increasing quantities of special and continuously cast steel. Production of/special steels including micro alloyed high strength steels has increased to 15% of the total steel production in the recent year. While we made some progress in production of micro alloyed steels, our efforts in research and development have to be further intensified to develop new and better quality steel products.

Processing of liquid steel through a continuous casting rather than the ingot route improves overall yield by 8-10% reduces specific conversion cost of finished products, apart from saving energy. Rapid growth of continuously cast products is evident from the following table.

Country	1974		1981	
	Mt	% of total crude production	Mt	% of total crude production
Japan	29	25	72	71
EEC	20	13	57	45
USA	11	8	23	21
USSR	7	5	16	11

Till recently some of our mini steel producers were using continous casting technology for casting of billets. First major continuous casting facilities are being introduced at Bhllai where entire expansion capacity (1.5 Mt) will be continuously cast into slabs and blooms. Similarly at TISCO a beginning has been recently made where a high capacity continuous billet casting unit has been installed. The new steel plant at Vizag is being built with 100% continuous casting facilities which means entire crude steel will be continuously cast.

Shaping

Primary hot rolling mills for shaping steel ingots continue to be the work horse for our existing integrated steel plants. The new is steel plant at Vizag is being built with 100% continuous casting avoiding completely primary hot rolling. In industrially advanced countries and specially in Japan, primary rolling mills are being phased out. In Japan, more than 80% of steel is being continuously cast to the economic advantage of Japanese steel industry. Japanese steel industry added 10% to their crude steel capacity simply by phasing out the primary rolling mills. Direct rolling of continosly cast product is more and more being adopted to effect maximum saving of specific energy consumption. Massive investment in the Japanese steel industry during the past oil crisis period was directed mainly towards adoption of these types of measures so that they are able to produce steel at most cost effective manner.

We shall be achieving about 25% continuous casting in our crude steel production by 1985/86 when the first phase of Vizag steel plant is expected to be completed. It will be necessary to phase out the primary rolling process progressively through modernisation process.

Most of the long product rolling mills in our integrated steel mills have medium to low capacity as oompared to the contemporary rolling mills for sImilar products. At Vizag modern hfgh capacity rolling mills are being introduced for the first time in our steel industry. Our steel industry has to continue with these long product mills for years to come as replacement of these would call for huge capital. Modernisation to incorporate maximum automation and to improve product qualities have however to be considered to derive maximum cost benefit.

In the areas of flat products, new flat product mills are being added at Bhilai and Bokaro. While at Bhilai a high capacity modern plate mill has been added, at Bokaro modern multi-stand cold rolling mills with hydraulic automatic gauge controls are being added.

There have been phenomenal developments in the flat product hot and cold rolling mills to increase mill productivity and improve product quality. In the areas of hot strip mills, on line computer controls have been introduced to increase mill productivity. Similarly, automatic gauge control and shape control devices have been introduced to produce hot rolled sheets of more exacting properties relating to shape and thickness tolerance. These devices need to be introduced in our existing mills through modernisation process.

Modern plate mill with back up roll bending systems are necessary to produce plates with exacting shape. Similarly, resorting to thermo-mechanical rolling in plate mills to produce plate with enhanced mechanical properties is being practiced by industrially advanced countries. This not only obviates the need of post heat treatment of rolled plates thereby, reducing the energy requirement, but this has become a powerful tool in the hand of metallurgists to produce high strength plates for various sophisticated needs.

In the areas of coated products, we lag behind not only the industrially developed nations but many developing nations. India possibly is the only steel producing nation with this size of the steel industry which is yet to produce many types of organic and color coated steels, tinfree steel, sheets coated with zinc and aluminium alloys and the likes. Similarly, there are many primary steel products which are yet to be produced in our steel plants like universal beams and columns section, controlled cooled wire rods, grained oriented and non-oriented cold rolled electrical steels etc. It is heartening to note that at Vizag uni.versal beam sections as well as controlled cobled wire rods and at Rourkela cold rolled electrical steel sheets are being introduced for the first time.

The large flat rolled products producing centres at Rourkela and Bokaro have to introduce new and better products so that the down stream steel using industries can also develop their products with new ideas, new looks and in more cost effective way.

Continuous annealing and processing of sheet gauge materials was developed to bring revolutionary changes in the production technology of sheet gauge materials. Many steel producing countries in the east and west have adopted this Japanese technology.

Thus for shaping of steel while we have to modernise our mills to derive cost advantage, we have to continue with our efforts to manufacture new and better steel products to derive overall.

Instrumentation

Further areas of emphasis are more sophisticated process control in all stages of iron and steelmaking. This would require application of instrumentation with improved accuracy. In this respect apart from the use of radiation thermometer, other devices based on electric infrared scanning system, electro magnetics, ultrasonics and micro wave technique are also being deployed. Development of probes for oxygen measurement in liquid steel and for monitoring gas composition (especially SO_2, NO, NO_2) and particulate densities for stack, gas is worth mentioning.

Modernisation of instrumentation system has to be brought; about to effect economy and to produce better product.

Automation

Automation in the steel industry in the developed countries is no longer an option but it has become the need. Macro, Medi and Micro computer systems have been built for blast furnaces, converters, continuous casters, strip, pipe and plate mills. Software and hardware can define, watch-dog and control any of the processes, integrate and orchestrate them into an optimum production schedule at a high level of efficiency. The biggest accomplishment of computer control systems is that they have made each stage of the ironmaking and steelmaking process more reproducible. The automation of rolling mills has resulted in significant improvement in yield and reduction in energy consumption. Process computers are efficient and major tool in ensuring precision control of every phase of operation.

Environmental pollution

Environmental pollution control is no longer a slogan but has become a reality. Most steel producing countries have more or less extensive set of legislative regulations in this direction. Steel industry is presently burdened with huge unproductive capital required for pollution control measures. For example 14-18% of total annual capital expenditure running into hundreds of million of dollars are committed every year in US steel industry to pollution control measures.

Most characteristic of the formerly poor image of steel industry was severe emission from converter and refining furnaces. However, with introduction of primary deducsting installation the task is left to the reduction in fugitive fume emission from coke oven plant, sinter plant, blast furnaces and other units.

Regarding water pollution, modern plants make use of water circulation system. However, cleaning of waste water from coking plants require expensive biological treatment as well as mechanical cleaning. Waste pickle liquor from cold rolling plants also pose problem.

With regard to dumping of solid wastes, the steel works, today practices a total recycling approach to overcome this problem.

Protection against noise is another difficult and expensive area which need to be tackled.

Statutory regulations in India have made it imperative for Indian Steel Industry to immediately take adequate measures to keep the pollutants within permissible limit, while some of the modern pollution control measures are being introduced for the first time at Vizag Steel Plant, the other Integrated Steel Plants have yet to take adequate measures in this direction.

Infrastructure

Steel industry requires maasive infrastructure support, inadequacy of which leads to low capacity utilisation. Meticulous planning and implementation are necessary to develop raw material bases, augment power generating capacities, exploit water resoures, expand road ways and railways, etc. Most of the infrastructure requirements are, to be integrated, with the rational requirements in other sectors and has to be tackled as such. Acute shortage of power, transport bottlenecks and irregularity in supply of coal to our steel plants have resulted in lower capacity utilisation.

STRATEGY TO MEET THE CHALLENGE

Thus we see that in addition to problems in market front, the Indian steel Industry faces numerous challenges in the area of raw materials, energy and techno1ogical obsolescence.

In the raw materials front, many research organisations are engaged in the areas of beneficiation of iron ore and coal with a view to reducing alumina content of iron ore and ash content of coa1. To take care of higher fines generated during iron ore mining operation and to optimise the blast furnace burden thereby increasing the productivity, new sintering capacity need to be created in the integrated steel plants to increase the sinter content in the burden to around 70 to 80%. Intensification of blast furnace oparation has to be introduced in the existing plants as well as new plants in order to improve productivity, reduce coke rate and thereby reducing the cost of production.

For reduction in energy consumption and to improve productivity, the existing open hearth process of steelmaking has to be phased out in which a beginning has already been made at TISCO. Similarly, continuous casting technology has to progressively replace the primary rolling mills in our existing steel, plants and has to be adopted in the new plants. All attempts have to be made to save energy by introducing energy recovering systems. Introduction of appropriate, technology for substitution of metallurgical coal with weekly/non-coking coal has to be made.

In order to do away with the technological obsolescence, it will be required to implement modernisation measures for upgradation and modernisation of deficient and outdated areas of technology, process, plant and equipment of the existing steel plants in the country. In these modernisation plans, various technological innovations like appropriate raw material preparation including base blending of sinter-mix, selective crushing of coal, coal dust injection, external desulphurisation of hot metal, combined blowing practice in basic oxygen furnace vaccum treatment of liquid steel, introduction of modern instrumentation and computeriasation for plant and process control aloingwith pollution control facilities are to be introduced.

Infrastructure support like, transportation, electric power supply, etc need to be augmented to do away with the existing uncertain positions in these areas.

But all these are only the beginning. We have to continue with our modernisation processes as the technology is not static. Continuously it has to be upgraded and innovations have to be brought about. We have to intensify our efforts to develop new processes, new products etc to make our presence felt in the steel world. The immediate goal for us therefore is to attain technological self-reliance specially in the areas of:

i) development of process technology and related engineering

ii) consultancy, project design and detailed engineering

iii) design of plant and equipment

Regarding development of new processes and products, updating and modernisation of existing processes with a view to reducing production cost and to bring overall economy by making best use of the available natural resources, raw materials, fuels etc in the country, although various research organisations including Steel Plants research divisions are engaged in carrying out developmental work, generally speaking our success in this area has been very limited in the past. For developing our capabilities in these areas the following need consideration:

a) large scale augmentation of efforts towards Research & Development

b) create suitable environment which will motivate people and attract new talents

c) close coordination between industry and research organisation and educational institutions including interaction with industrially advanced countries in speciflc areas

d) more efficient organisational set-up and close interaction between design, engineering & R&D organisation.

In the areas of consultancy, project design and detailed engineering, a reasonable degree of self-reliance has been achieved. However, continuous developments are necessary specially in the areas of detailed plant engineering.

Regarding design of plant and equipment including their systems, unfortunately there have not been sustained and basic type efforts in this direction. While some actions for developing expertise for some of the disciplines like rolling mills, processing lines, coke ovens have bean taken, the same cannot be said true for other areas. To achieve technological self-reliance in the vital araas of equipment and system design, it will be necessary to acquire the technology from industrially advanced, countries and absorb the same so that we can have sufficient mastery over the technology. We have to have suitable organisations to absorb the borrowed technology and bring innovations through our own research and developmental efforts. Japan for example, spends about seven times as much on R&D for development of technology on each dollar paid for its import for the same. Our corresponding expenditure is about 1 to 1.5 US dollar. Industrially advanced countries have been exchanging 90% of the world's technology amongst themselves. Countries like Japan, USSR, West Germany, France, UK and USA are importing technology on sizeable scale. India is spending less than 1% of the export earning on import of technology as compared to about 3% by the advanced countries. So, it will not be out of place if India goes in a major way to import technology for vital areas.

FUTURE PROSPECTS

Steel is the basic raw material for industrial development of any country. Every country engaged in industrialisation must be concerned about its day to day supply as well as long range availability to support industrial growth. The past has shovm that the demand of steel suffer eylice fluctuations its in own way. Since the, oil shock in 1973, all demand forecasts have not come true and presently steel demand forecasts are not being made as hitherto been done. Novertheless, experience has shown that the steel intensity of an economy (defined as the ratio between steel consumption and real GNP or GDP) depends on the stage of economic developments reached by the country.

There are four clearly defined stages in the development of steel consumption in all economics. First, while a country is still at an early stage of development, is teel intensity is low. In thes econd stage of economic take off steel consumption grows much faster because of rapid indutrialisation and establishment of an infrastructure. In the third phase of development when an infrastructure and significant degree of industrialisation has been established, the rate of growth of steel consumption is more or less the same as GDP. Finally as the industrial growth maturity sets in and more sophisticated, industries and services begin to represent a significant share of the economy, steel consumption falls behind, the GDP as in the case of highly developed countries in the west.

India being at the threshold of economic take off with the present level of per capita consumption of 17 kg/yr has an enormous potential for steel consumption. The demand of steel is bound to pick up at an accelerated rate to support our industrial activities. We have, therefore, to gear up ourselves to produce more and better quality steels in most cost effective manner using our own raw materials, human talents, machineries and systerns.

All these would necessitate successfully meeting the several challenges the industry is facing today through our modernisation efforts, stepping up research and development activities, strengthening know-how capabilities and machine building base, bringing new culture for quality consciousness, technical discipline and hard work. This will go a long way in shaping and rejuvenating our steel industry.

Finally, steel industry being capital intensive requires mobilisation of large resources for its modernisation and expension. Presently, the country is facing acute shortage of finance and foreign exchange. The availability of funds is a major constraint for the steel sector. Steel industry has to rise to the occasion in overcoming this constraint by its own effort to generate economic surpluses. This can be achieved through the multipronged approach of technological self~reliance and research & development effort which will show a new way and direction.

I have no doubt that our, steel industry will come out of the present crises and it would establish its viability to bolster economy.

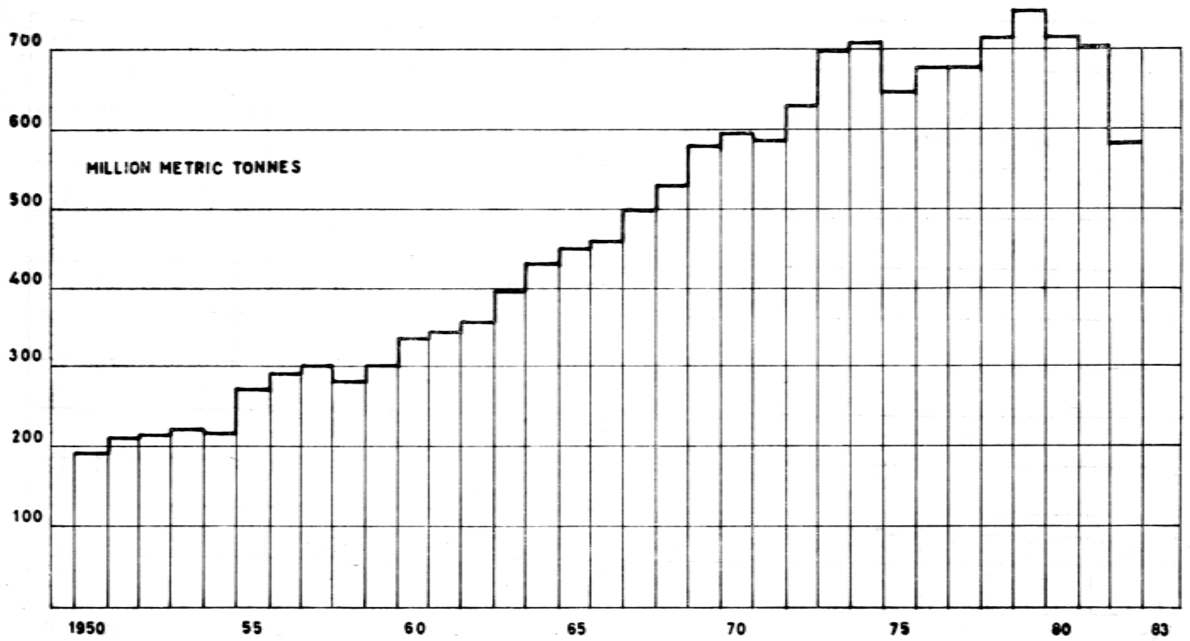

Fig 1 World Crude Steel Production, 1950 to 1982

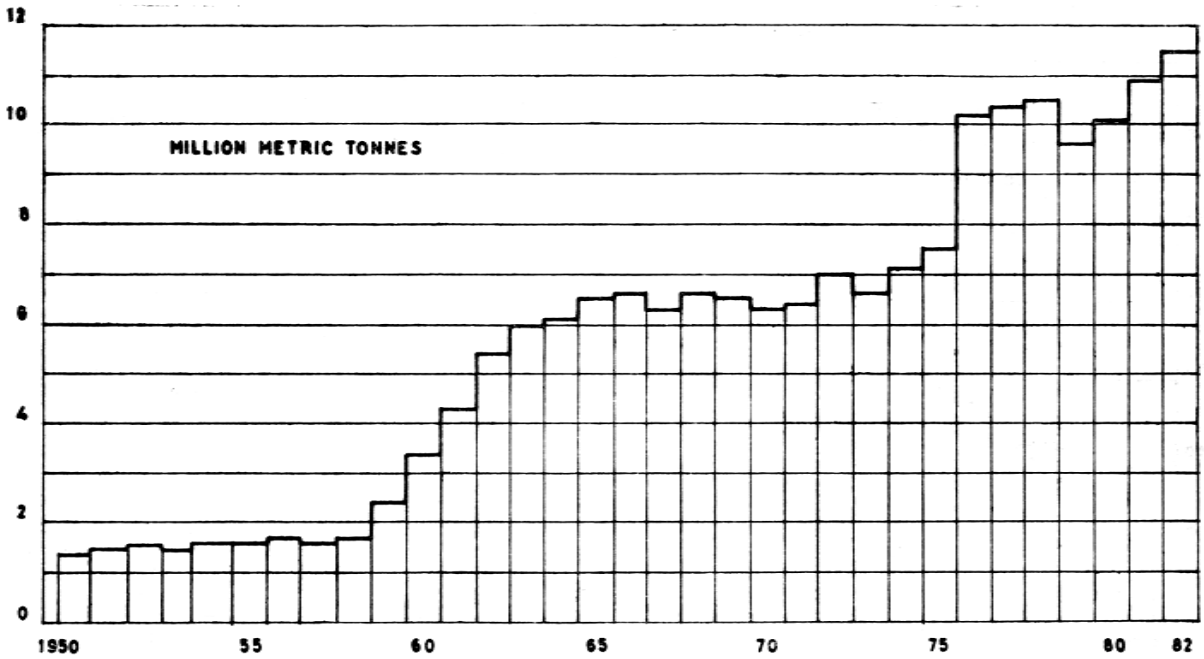

Fig 2 Indian Crude Steel Production, 1950 to 1982

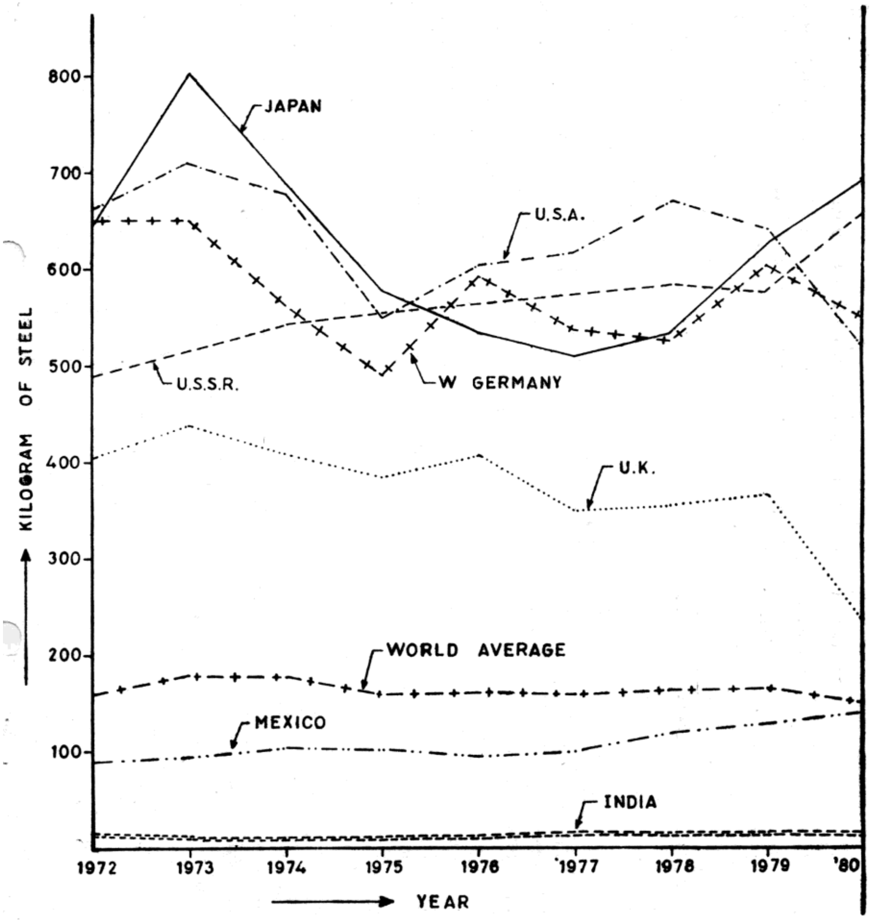

Fig 3 Apparent Steel Consumption (Kilograms crude steel equivalent)

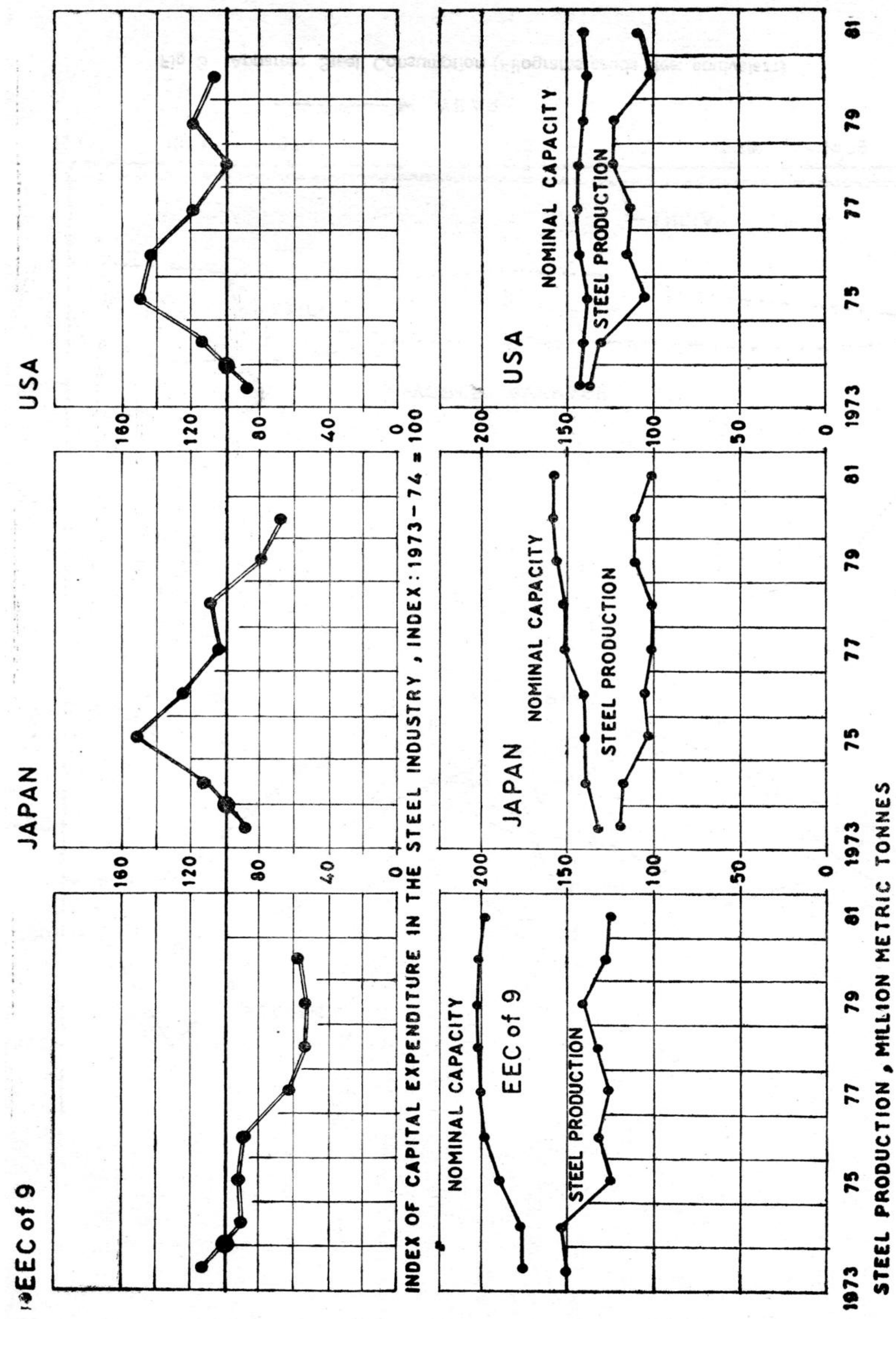

Fig 4 Steel Production, Capacity and Capital Expenditure

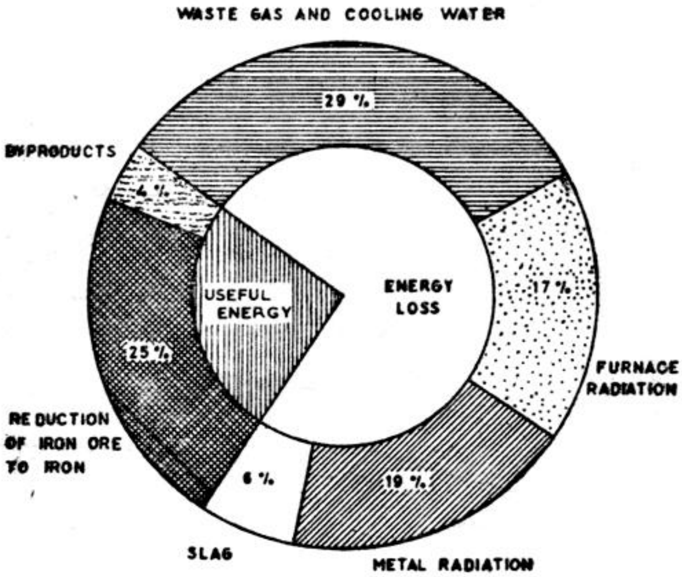

Fig. 5 Steel Industry Energy Utilization Pattern And Distribution Of Losses

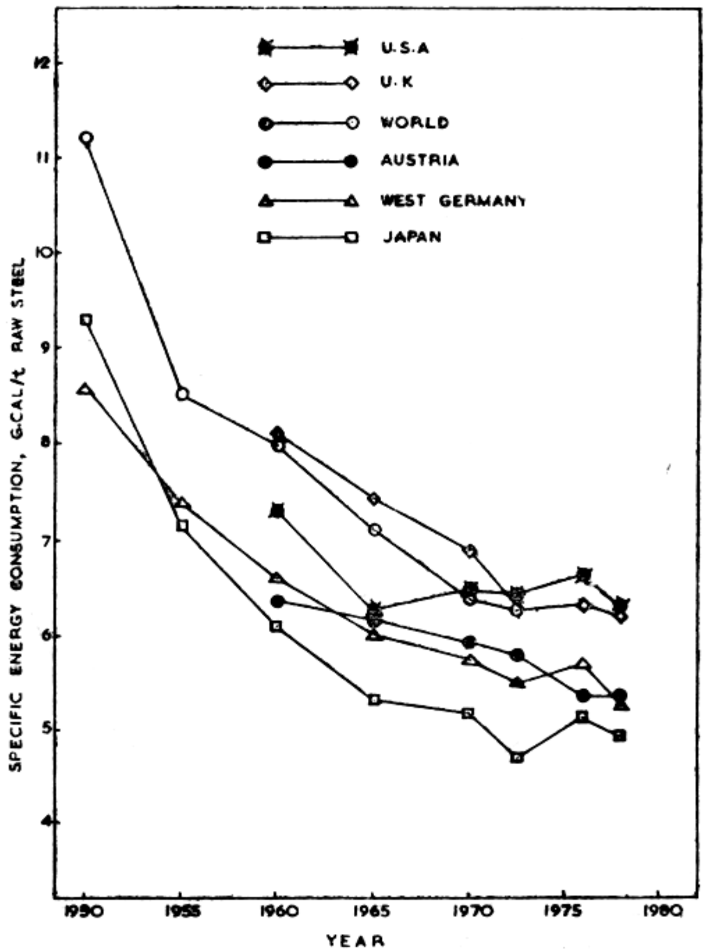

Fig.. 6 Specific Energy Consumption Data For Steel Plants—Country Wise

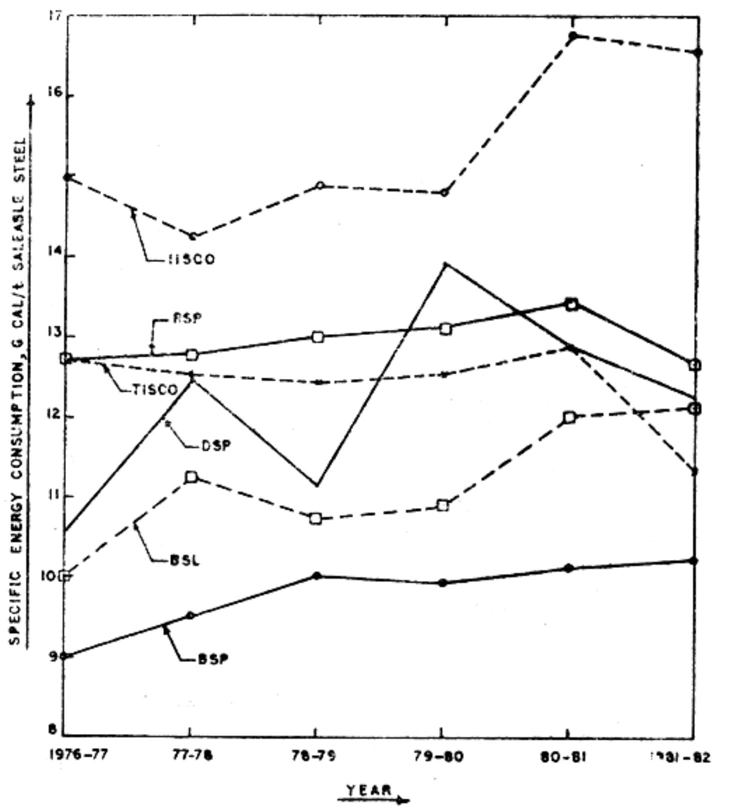

Fig. 7 Specific Energy Consumption Data For Indian Steel Plant

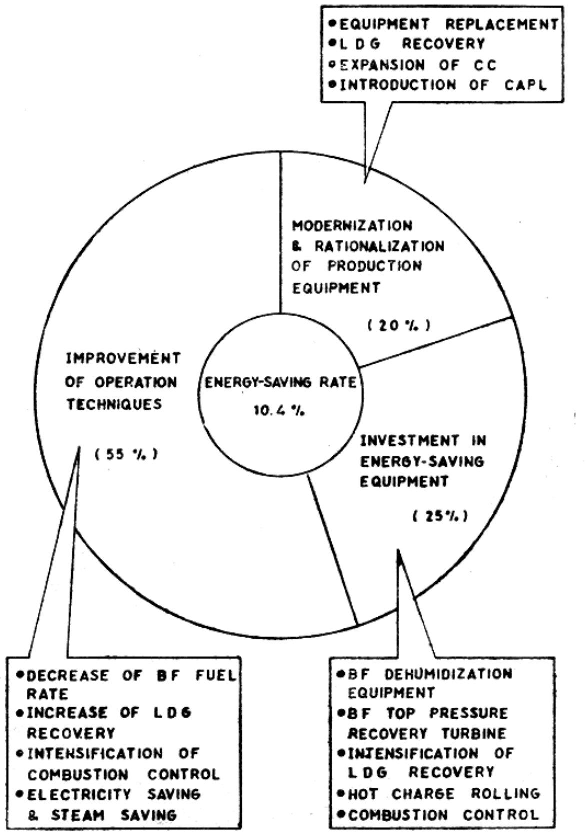

Fig 8 Contribution of Various Measures To Fnergy Saving In Japan After First Oil Crisis

Table-1

World trends in production, consumption and apparent consumption expressed in terms of crude steel

Country/ region	PRODUCTION, Mt 1950	1960	1970	1980	1981	Ratio of 1981/1950	CONSUMPTION, Mt 1950	1960	1970	1980	Ratio of 1980/1950	PER CAPITA CONSUMPTION, kg 1950	1960	1970	1980	Ratio of 1980/1950
Developed,	184.0 (97.9%)	318.6 (91.9%)	551.7 (92.7%)	614.0 (85.6%)	605.7 (85.6%)	3.3	NA	314.9 (90.9%)	529.1 (88.9%)	576.9 (80.4%)	1.8 (1980/1960)	NA	329	492	494	1.5 (1980/1960)
of which																
USSR	27.3	65.3	115.9	147.9	149.0	5.5	26.6	63.5	110.2	152.2	5.7	159	296	454	573	3.6
USA	90.0	90.1	119.3	101.7	108.8	1.2	86.0	90.5	127.3	118.4	1.4	565	501	620	520	0.9
Japan	4.8	22.1	93.3	111.4	101.7	21.2	4.2	19.5	69.9	78.0	18.6	57	209	676	668	11.7
West Germany	14.0	34.1	45.0	43.8	41.6	3.0	10.1	29.2	40.6	35.4	3.5	238	527	660	575	2.4
France	8.7	17.3	23.8	23.2	21.2	2.4	6.7	13.9	23.2	20.0	3.0	195	306	457	372	1.9
U.K	16.6	24.7	28.3	11.3	15.6	0.9	14.0	22.2	25.5	19.5	1.4	292	425	458	349	1.2
Developing	3.9 (2.1%)	27.9 (8.1%)	43.7 (7.3%)	103.2 (14.4%)	101.6 (14.4%)	26.1	NA	31.6 (9.1%)	66.3 (11.1%)	140.3 (19.6%)	4.4 (1980/1960)	NA	15	25	43	2.9 (1980/1960)
of which																
China	0.7	18.5	18.0	37.1	55.6	50.9	1.2	19.2	22.5	42.4	35.3	2	27	29	44	22.0
Brazil	0.8	1.8	5.4	15.3	13.2	16.5	1.0	2.7	6.1	14.6	14.6	22	41	64	119	5.4
South Korea	-	0.1	0.5	8.6	10.8	108.0 (1981/1960)	NA	NA	1.1	6.1	5.5 (1980/1970)	NA	NA	33	160	4.8 (1980/1970)
India	1.5	3.3	6.3	9.5	10.7	7.1	1.8	4.6	6.4	11.4	6.3	5	11	12	17	3.4
Mexico	0.3	1.5	3.8	7.1	7.6	25.3	0.7	1.7	4.2	10.2	14.6	33	50	82	142	4.3
Argentina	0.1	0.3	1.9	2.7	2.5	25.0	1.0	1.6	3.3	3.8	3.8	57	76	135	140	2.5
World total	187.9 (100%)	346.5 (100%)	595.4 (100%)	717.2 (100%)	707.3 (100%)	3.8	187.9 (100%)	346.5 (100%)	595.4 (100%)	717.2 (100%)	3.8	75	114	162	162	2.2

NA - Not available

Assumption : Total world steel production = Total world apparent steel consumption.

The Nineteenth Nidhu Bhushan Memorial Lecture was delivered during the Sixty-fifth Annual Convention, Jaipur, February 15, 1985

Man-Machine Symbiosis — Key to s Viable Future

Prof S Sampath, *Fellow*

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I am deeply beholden to the Institution of Engineers (India) for this honour that I have received in being invited to deliver the 19th Nidhu Bhushan Memorial Lecture on the occasion of the 65th Annual Convention at Jaipur. In the words of Albert Einstein: "The future is always a period of hazards, perils and uncertainties. Butthe world goes on and finds solutions to its problems by following the examples set by pure and noble characters: An occasion such as this is a time for reflection on the value-system cherished and practised by one whom we are remembering gratefully and honouring today. It also gives us the opportunity to rededicate ourselves to the pursuit of the unfinished tasks and to endeavour to foster an attitude that promotes excellence and contributes to the country's progress in science and technology.

I have chosen, for my lecture, the theme: 'Man- Machine Symbiosis-Key to a Viable Future'. I shall present it under the following sub-heads:

- Complexities in the decision-making process
- Machine systems built with human attributes
- The simulation of the human brain-challenges
- Will some day computers become cleverer than humans?
- Computers as aids in designing

As I progress through my talk and dwell on the interaction between man and machine, you may get the feeling that I tend to run with the hare and hunt with the hounds. This, I may submit, is the essence of the dilemma that we face. I express the hope that the march of science will illuminate the pathways that we have to traverse to reach a higher level of understanding of the basic issues before us.

THE COMPLEXITIES OF THE DECISIONMAKING PROGRESS

Today, we are ruled by the tyaranny of small decisions. We tend to focus on the shortranqe and the expedient. We react to the needs of the moment. We make decisions, which individually seem to be of modest Significance, without fully grasping their implications. After a series of these 'small decisions', we find that we are locked into disastrous patterns that defy our capacity to break out of them. All about us we see examples of major problems resulting from such a cumulation of small decisions that now demand solutions: the problems of our cities; transportation; the distribution of medical services; the environment; and the education system.

We will be able to do a great deal with systems analysis and program planning, using new analytical tools that are now available not only to solve the kinds of problems that we faced in the past but to ensure a decision-making process that will help to avoid in the future the mishandling of the more complex problems that will continue to arise in the future. I new quote, 'The modern age has a false sense of superiority because of the great mass of data at its disposal, but the valid criterion of distinction is rather the extent to which man knows how to form and master the material at his command.

This passage was not written in 1975 or even in 1950. It dates back to 1910 and was written by Wolfgang van Goethe. Its appropriateness and applicability to the conditions of today are beyond question. It sums up admirably today's problems. We have vast quantities of data, and we have enormously effective means at our disposal to manipulate the data. Yet we have given too little attention to the heart of the problem. We make use of the latest in technology, but we devote scaut attention to the critical factor in decision-making, namely, the intelligent use of data. We need to give much more formal attention to the design of decision-systems and information flow patterns. One problem we face is as to how we test the validity of the data that we receive. Another is as to how we may build system which incorporate the political, social, economical and environmental information needed for genuinely useful decision systems. Such systems, we may surmise, will represent major commitments of manpower and money. They will call for inputs from many discipline, but most of all f rom the realm of social sciences. We have many tools and techniques, and the great task of the synthesis of these into a formal discipline appears to have just begun. We are all, in a sense,·pioneers in this effort.

In considerinq the formulation of a strategy, the ingredient is not long-range planning alone. This has to go side by side with planning for change and its counterpart planning necessitated by changes. Product lifes have been shortened as also the life of the processes-industrial as well as business. But the reaction-time of management today tends to be long. Too many managements are content to wait and watch what happens and either follow the one who leads or let others make mistakes which they can avoid. We are increasingly encountering situations for which there are no precedents. We are now obliged to make many decisions without historical precedents. This implies a whole new area of intellectual competence which is not only mathematical but organizational and inventiona.

Decisions will now have to be made in areasthat are scientific and technical by people who have no back-ground or experience in these areas. As we encounter more and more situations in which science and technology hold the key to success or failure, we will face different problems in the choice of those who will make decisions. We need managers who will not only manage but will understand technology. We also need scientists who will stick to science and remain scientists. Can we afford the continual draining off of our best brains for the role of managers? We need then managers who will have to make decisions previously made by a scientist or a group of scientists.

Whoever makes the decision, it is of crucial importance for him to have the ability to make the right kind of decision on data that become available. As we enter upon a world in which we may increasingly collect all the data that we want, the premium will be on our own capacity to pose the right kind of question and to be able to interpret the results in a perceptive manner.

The forces that we have to contend with are probabilistic in nature. In forceeing the circumstances that will prevail tomorrow or the day after and, in assessing the cause-effect relationships, one is obliged to bring in probabilistic estimates. Added to this is the nature of the value-system in which we are embedded. The same act and the same outcome will have different meanings and values for different groups of people and different societies. For the same people and the same society, values change with time.

To minimize chaos and disorder, it has been customary to add to the existing bodies of laws and regulations and to order revisions from time to time ane build up patterns of regimentation to control and direct the activities of people. Rule-making has invariably been based on symptoms-analysis and it quite often is ignored or, worse till, is interfered with feedback flows. In essence,these procedures generated more problems than they were able to solve; and they yielded a multitude of problem-perpetuating approaches. Organizational structures have grown to a point where they now control the people who were expected to control the functions of the systems.

The swift increase in the amount of information to be received, sifted, analyzed and structured for decision-making has outstripped the capacity of the conventional systems at our disposal. Our brain-power is at a loss when we are confronted by the great accumulation flow of information associated with complex decision-making. We cannot conceivably process the numerous variables and references into useful patterns which the brain can easily encompass and deal with unless we are in a position to use advanced computing aids and techniques.

Engineer-scientist, Daniel E Noble, who has made a critical study of the situation, suggests a line of action in these words:

'All growing systems in our bio-spherefollow S-curve with exponential growth, followed by a drop-off to a state of equilibrium assaturation and feedback effects come into play. In acomplex system, many feedbackforces are involved and the interplay of feedback influences will provide numerous statistical sub-cycles all of which may not be discernible through the complex curtain of the forces at work. It is only through the use of appropriate filtering techniques and models that some of the concealed short-term economic cycles can be brought to light and these will reveal immediate trends and illumine the leverage-points in the system at which timely intervention may be made to induce favourable change or at least help to mitigate the intensity of the undesirable stresses impinging on the system. Towards this end, we should make monumental use of high· speed electronic brain extension systems. We ought to pay special attention to the setting up of effective dynamic modelling techniques.'

The above is not to be construed as an inescapable call for the installation of large and powerful computer-systems to Speed up data processing in a complex organizational set-up. It is well recognized thatthe unimaginative provision of raw computing power in several instances has merely led to the accumulation of large volumes of unwanted data, making the entire exercise counter-productive. The critical need is the restructuring of the organizational and administrative machin-erythat one has to deal with, using a systemsdynamic model that is nourished by a network of well-designed information flow channels. As people are involved, one has to deal with non-linear changes and subjective forces. The USeof academically conceived, pure mathematical models will lead to an over-simplified representation not in keeping with reality. The modelling systems designed Should be capable of taking into account and rationalizing the subjective nature inherent in the people-forces that condition the working of our environment and influence the economic and social parameters that affect it. In creating an interface between man and machine, the objective should be to seek a fusion of man's creative ability and sensitivity with the machines infinite capacity to pay undivided attention to minute detail.

MACHINE SYSTEMS BUILT WITH HUMAN ATTRIBUTES

Recent years have witnessed a thrust toward the creation of machine systems that imitate with varying degrees of success human attributes such as seeing, hearing and speaking and attempt to simulate the responses of the nervous systems of animals and human beings. Machines have been built and taught to run mazes, use short-circuits and proceed to prescribed goals without making any error or wasting any effort. The mechanical twin tortoises, called Elsie and Elmer, with thsir strangely life-like movements, the squirrel picking up nuts and the octopus that identifies geometrical shapes belong to this class of devices. These are the forerunners of 'learning machines' such asthe device that is designed to look at a Shopping list and help in the ordering of merchandise; the one that reproduces human voice with theaid of a speech synthesizer; or the one that can recognize and respond to words spoken to it. The motive for producing devices which simulate the human hand and arm comeS from the ato:nic energy field where robots have been built to handle radioactive materials. A crucial problem in such devices is to give them a sense of the resistance that is offered to their movement. Several yeara ago, the General Electric Company of USA successfully developed a device with this kind of sensitivity. Named Handyman, it can twirl a hulahoop in an action which involves feeling the 'pull' of the hoop and timing the impulses to fit it, and, in a demonstration given before a group of awed spectators, it picked up a small girl fro.ll the floor and later put her down gently; if it did not have the feedback mechanism, it might have hurled the child through the ceiling of the room.

The steps toward achieving such man-machine symbiosis are being taken today not by a few visionary scientists working in their ivory-tower laboratories but by teams of engineers, mathematicians, biologists, surgeons, chemists, neurologists and communication specialists; significant work has been done in the area of artifical organs; plastic or electronic substitutes for either a part or the whole of the organs of the human body such as the heart, the liver or the spleen. Several cardiac patients are alive today because they carry pace-makers in their chest cavities; and many have heart-vlaves made out of dacronmesh. Implantable hearing aids, artificial kidneys, arteries, hip joints, lungs and eye sockets are in various stages of development. Medical technology i busy building tiny sensors that may be implanted in the human body and used to monitor blood pressure, pulse, respiration and other functions, together with a transmitter that will radiate a signal when something goes wrong. There is a detector, for example, which can pick up signals from the nerve-ends at the stub of an amputated limb; and the signals used to activate a prosthetic aid, thereby making a machine directly and sensitively responsive to the nervous system of the human body. The goal sought to be reached in this area is that the person need not 'think out' his desires and that volunatry imuplses will do the job; the responsive behaviour of the machine is sought to be made as automatic as the action of one's hand, leg or eye.

A medical institution in the USA has undertaken a research project on the construction of a television camera that can take the place of a defunct eye in a human being and on the devising of methods by which the siqnals from the camera could be fed to the brain and made to actuate its cells so as to bring vision back to the blind man. The leader of the research team identifies this project and projects such as these to be more importa nr, in human terms, than the space Mission that succeeding in putting a man on the moon.

Dr Taylor of the University College, london, has designed an 'eye' consisting of an array of photoelectric devices to serve as the front-end of a set-up that attempts to recognise shapes. This experiment is designed to throw light on the manner in which the brain forms concepts. His colleagues have built a mechanical finger which learns, by trial and error, to turn itself toward a spot of light in its field of view; and this effort is modelled on a principle believed to be employed by the brain. Two physiologists, Hubel and Wiesel, have demonstrated the character of brain cells involved in abstracting notions like 'anqularity' and seeks an understanding of concept formation at the neuronal level. Scientist, Gordon Pask, has built a computer-like device, called Eucrates' which can teach other similar devices that it has learned. Built into it are such traits as persistence' and forgetfulness' which may be adjusted to explore the best methods of teaching in different circumstances. John Loehlln, at the University of Nebraska, USA, has been working on a computer program which provides a model of personality. He has named it 'Aldous' and has equipped it with three emotions-love, fear and anger-which are graduated in ten stages. A strong emotion tends to subdue a weak one. The device is equipped with two types of memories-a short-term one dealing with current situations, and a long-term one based on the accumulation of past experience. The situations studied are classified as 'satisfying,' 'painful' and 'frustrating' in various degrees. Aldous has been programmed through constrasting lives and its behaviour and attitude are found to depend consistently On its experience in a given life. It has been, in turn, gullible, bold, sceptical, hesitant or decisive. It is a primitive model used to explore problems in psychology. It is not equipped with elements representing traits such as 'unconscious', 'initiative,' etc. Yet it undoubtedly stands on the threshold of an evolutionary development.

An even higher level of capability is embodied in the question: Can a machine system be built that will function somewhat in the manner of the human brain '1 The brain does not simply stores digits as computers do. It forms concepts. If computers can be made to do this, man will have achieved the creation of artificial intelligence. The sophistication of the human brain is way beyond the capabilities of the biggest and the most modern computers available to us today. Yet the problem is under attack.

Many yeara ago, Russian scientist, Prof lebedev expressed his view that man is a clumsy creator and will not be successful in building a machine with the generalized intelligence of even a tape-worm. When someone said: 'A tape-worm cannot translate texts from one language to another'. His rejoinder was: 'But the tape-worm gets along without programming assistance from man!' Scientists at Standard Research Institute have, over the years, developed a machine to match the generalized intelligence level of a four year- old child. It has an inner-core built to resemble the central nervous system of human beings, with provision for sensation reason, language, memory and ego; and a memory-store of millions of bits of information to draw from. The system has cost quite a lot of money, yet it is primitive by human standards.

Current achievements of computers are based on rather straight-forward capacities. ,. hey have to be told before hand in meticulous detail what they have to do; they can do nothing by themselves. From this point of view, they deserve to be, and often are, described as moron. But, even in this limited context, interesting examples of computer-capabilities may be cited. For instance, it is feasible to put crime-records into the capacious memory of a large computer system and set it the task of predicting when the next crime in a series is likely to occur, because the computer can be taught to analyze the preferred modes of action of different criminals. It is equally feasible to call upon a computer to verify the authenticity of disputed literary works, eg, St John's gospel and the Dead Sea Scrolls. It is well-known that every writer has a preference for words and phrases which he uses with a frequency that stands out like his finger-print and the machine can be programmed to identify these preferences.

Will computers ever be able to write symphonies devise cosmologies and conduct psycho-analysis? One answer to this question is that the computer can do any operation for which rules can be written and it is up to the rule-writers to decide what can be done. It is in pursuance of this approach that computers have been orqanized to perform tasks like translating texts from one language to another, writing poetry or composing music. Many amusing results and some limited success have come out of the efforts; but refinements are bound to follow. These tasks are not, in their own right. examples of creative thinking. The design of the so called learning machines represents the first step taken in a new direction. Early designs of these have chiefly been concerned with being able to instruct machines to play games. Draughts and chess have sets of well-defined rules and objectives that are capable of being translated into programmes which present day computers can cope with. The computer would be made to stores in its memory the results of a long series of games and the moves made in them with their consequences and taught to be able to survey the position after each move and sbusequently make those moves which most frequently resulted in wins in the past. The game of draughts is relatively simple and today's machines have the upper hand over the human player all the time. But in the game of chess, which is far more complex, the man-machine duels have had their ups and downs over the years. At this point of time, we have to concede that the electronic computer is liable to be beaten by the master chess-player, because it is not equipped with the spark with which the champion makes his victory yielding moves.

Can we be complacent that such a machine with these extra attributes will never be built ?

There are flashes that suggest that astonishing breakthroughs are around the corner. Although computers have been primarily designed for deductive operations, they can be and, in fact, have been, programmed to perform inductive ones as well. There is the isstance of a machine producing a new brilliant solution to the problem of finding a proof for a theorem in mathematical logic that both Bertrand Russel and Alfred North Whitehead had missed. This programm, called the 'Logic Theorist,' was developed in 1956.

The sophisticated computer systems of today are beginning to blaze new trails in problem-solving, markedly different from those traditionally practised by human beings.

One of these is based on the technique of using little knowledge and a great deal of aearch. A program, called DENDRAL, using this method has successfully arrived at the pattern of molecular structures of fantastically complex organic molecules using voluminous searah to propose and to rule out potential structures suggested by the laws of chemistry and atomic bonding. A research project, completed recently at Carnegia-Mellon, on the mechanism of human speech, employed the two alternative approaches and has concluded that searching was easier, more reliable and more cost-effective than the conventional knowledge-oriented approach, that has to cope with large chunks of data and information.

The validity and power of the search programme are under intensive study in the context of the development of chess-playing computers. Says Huns Herliner, an authority on the subject: 'A searching program's great strength is that it will look at every possibility to some arbitrary depth =-three moves, say, ahead-and then look at selected lines of the play beyond. Such thoroughness, combined with stodvness is well beyond human capacity. Even the world's best chess-player will commit simple over sights and the computer will quickly pounce on them. Whether all this makes up for the lack of conceptualization is difficult to tell at this point of time. 'Machines that 'learn' are very rudimentary; butthey have dernonstrated that learning is possible. How far way is 'Creativity'? Even computer scientists have their doubts that true creativity-the stuff of human emotion and deep experience-can ever be reached. Indian writer, Jagjit Singh, points out that there is a kind of indeterminacy that will ever act as a barrier to our understanding of the human brain and the quest for the secret of human intelligence will be long and ardous and, perhaps, never-ending. Yet we can deny that computers in our midst have altered man's assumption that he is the only thinking being on earth ?

SIMULATION OF THE HUMAN BRAIN-THE CHALLENGES

The brain consists of a large number of interconnected units capable of performing one simple function-transmit, or not transmit-a current. This is also the case with a digital computer. The similarity ends here and there are numerous differences. The designers of brain-like man-made mechanisms have to contend with three basic issues:

1. Memory capacity: The brain isfed with masses of information for years before it generates adult behaviour. T he information is partly consciously chosen and is partly the chance-result of random experiences and varying environment. Computers have selected information fed into them.

2. Concept-formation: The brain does not merely store digits; it forms concepts. T he sophistication of the brain, appears to be way ahead of the capabilities, and even ambitions, of todav's computer builders.

3. Association of feeling with data: Human beings not only think but feel. A record of the feeling gets inter-twined with what is remembered of factual data. This is a complex mental process and we do not know much about the physiological mechanism that is responsible. We may surmise that it has a connection with chemical activity in the brain. The computers that we know of are not equipped to deal with the chemical aspect that characterizes chemical activity.

We know a great deal subjectively and objectively about what the human brain does but less about how it does it. The brain is far more subtle than any machine devised by man yet. We know also that it operates on principles quite different from those of electronic computers. Experiments with electrodes tell us that the brain is an electrical machine with waves of activity sweeping through it. It is 'also a chemical machine and not just in the trivial sense that the body electricity is chemical in origin. The interconnections and interactions of the cells depend on chemical processes and memory involves the generation of large complex molecules.

The brain has an organizational style of its own. A computer has a comparatively small' number of components but it performs many thousands of operations in a second. The brain has many more components about 10 billion nerve cells; and it appears to use many of them in operation, just a few times a second. The lower, less sophisticated areas of the brain work more in the fashion of the computer than does the cerebral cortex, though still with notable different logical arrangements.

The brain· is an integral part of the living body sharing in lall its mechanisms, efforts, satisfaction and pain. Program and data are accumulated slowly in the context of emotions. T he psychologist speaks of the 'corruption' of pure rationally by the emotional memories associated with learning and thinking. The bio-chemist draws attention to the natural 'drugs' that the body deploys in response to circumstances which influence mood, thought and behaviour. T he neurologist pinp oints centres in the lower brain that are not passive bridges between the body and the upper brain but are responsible for 'drives' and emotional behaviour.

As scientific forces are building up for an assult on the centre mystery of the functioning of the human brain, there are conflicting views on whether we will ever be able to build machines which, by objective tests, will be seen to be as intelligent as human beings. Prof Harbart Dreyfus, of the University of California, USA, is convinced that computers will never be able to think because they are deficient in autonomous desire or free-will and, more crucially, because thought is not amenable to the step-by-step routine on which digital computer working is based. On the other hand, Dr Block, of Cornell University, USA, is of the view that there is no task that can be named today that a machine cannot do in principle. He says: 'If you define a task and human bein.g can do it, than a machine can, at least in theory, do it, though the converse is not true.'

WILL SOME DAY COMPUTERS BECOME CLEVERERTHAN HUMANS?

Educating one computer with the aid of another suggests some breathtaking possibilities. One bit per second has been estimated to be the safe upperbound for the amount of information that can be committed to long-term memory. This means that man who absorbs information for 16 hours a day over a life-time of 70 years, say, would store 109 bits. By coincidence, there are 109 neurons in the cerebral cortex. This order of core-store capacity and the devising of optimal codes to make use of it are well within reach of modern computing systems. The interesting point is that it would take only about 20 minutes to transfer 109 bits of information-the life-time experience of an individual, from the memory of one computer to another using currently available techniques. It appears therefore that it would be for more easy for computers to bootstrap themselves on to the experience of earlier computers than it is for man to benefit from the knowledge acquired and stored by his predecessors.

Misconceptions about the meaning of the term 'intelligence' have given rise to fantasies about computers in which either they take over control for the good of mankind or they plunge nations into the abyss of war. The stress on the style of operation of computers and their indefeatability and infallibility, have invested them with a cultural aura. We tend to refer to a person who retains in his head a lot of information, solves problems mentally and is seldom found making a mistake, as one with a 'computerllkernlnd.

Intrinsically, intelligence is synonymous with the pursuit of a goal for an independent, autonomous purpose. Its dominant ingredient is 'free will. This puts us on the horns of a dilemma. It is impossible for anything to be free and uncontrolled without its being indeterminate as well. In favour of computer, it may be urged that there is no difficulty in incorporating into them randomizing devices which will render unpredictable their response to situations.

The psychologist would argue that free will is more complex than this. The computer enthusiast will then challenge him to propose a test that can be administered to a machine to demonstrate that it has no free will.

The capacity to reason and to draw up deductive syllogisms is a distinctive hallmark of the humanmind. Logic is explicit, entirely conscious and has the ability to settle questions indisputably. Yet, it is useful in deaiing with only a small range of problems that we face in real life situations. Learning dedcutive logic is the process of picking up the capacity to say nothing that isnot a restatement of whatever is known or given.

The mathematical routines that constitute the core of computer programs correspond to deductive logic. The program called 'Logic Theorist', developed in 1957, was followed a few years later by the 'General Problem-Solver' which was devised to deal with a wide range of classical problems. If the ability to handle logic is construed as a vital 'intelligent' activity. These become impressive advances. In the euphoria created by them, programs were written to demonstrate that computers could play games, compose poetry as well as music and piant picture, find proofs for theorems in geometry and symbolic logic and simulate neurotic conditions and certain types of human emotion, WhIle specialists were striving to get an insight into 'intefligence', the man in the street began to believe that the key to intelligence was somewhere inside the machine and all that was needed was a program to trigger it.

These expectations have not come to pass. 'Intelligent' programs have remained for the most part laboratory achievements. Whatever results were achieved by them appear, in retrospect, to have been in contexts that were artificial and narrow. In each instance tedious and time-consuming labour was involved i~ preparing inputs for their execution; and even small changes in the problem formulation called for full scale repetition of the programm in effort.

‘Intelligence' implies the ability to link up with the world of realities to pursue a goal and to demonstrate competence over at least a small sphere of human experience. In spite of all the advances that have taken place with the availability of vary sophisticated equipment and with more scholars working in the area of search than ever before, machines matching human intelligence seem distant prospect.

A four-year old child would quickly recognize 8 number figure like '5', whether it is printed neatly in a book or scrawled by chalk on a black-board. Persuading the computer to make out the character even when presented in approximately standard style has proved to be exceptionally difficult. Machine-translation of texts, when anything beyond mere trans-literation is required, has proved to be elusive despite many years of persistent effort. Although automation of indexing and cataloging of library information has been successfully accomplished at the routine level, we are nowhere near matching human ways of thinking where the need is to translate a vaguely stated 'interest of the prospective user into a valid act of references, whereas a human librarian will take this task in his stride after a brief conversation with theuser. On the technical front, it has become practical to store all man's information in electronic systems and deliver any portion of it anywhere on demand. Practical difficuties in injecting information into the overall system and conceptual road blocks in the matter of retrieving it in meaningful parts and combinations tend to retard the realization of the full potential of all the sophisticated hardware that is now available. The reason for this is not far to seek; it is the year unbridged

gulf between the way human beings think and the style of working of tcdav's intelligence machines. Yet there have been achievements in the realm of intelletual discovery. As mentioned already, the program 'Logic Theoristthrows up a new brilliant solution relating to the proof of a theorem in mathematical logic which the most eminent mathematicians has missed. A program designed at Carnegie-Mellon, called BACON, was set to look for patterns in scientific data; and on its own, it 'discovred ' a rule of planetary mechanism first established by Johannes Kepler. When the system was fed all the facts that were known in the field of chemistry in the year 1800, it deduced at once the principle of atomic weight-a feat which human scientists were able to achieve only after 50 more years of hard work.

A decade ago, few would have believed that there would be a S 100 machine playing chess better than 95% of the population; or a set of programs that will interpet electro-cardiograms better than most doctors; or a program that would prospect for minerals.

Says Marvin Minsky of MIT, USA, 'It won't be long before we have in our midst machines car-able of solving any mathematical problem posed to them. programs will be written which will enable them to react reasonably well to significantly complex situations.'

Prof Herbert Simon, Nobel Laureate and a pioneer in the area of artificial intelligence has observed: 'The comp uter and V LSI are bringing our society its second Industrial Revolution. The real revolutionary aspect does not concern the number crunching ability of the computer but rather its ability to be a perfectly general symbol, manipulating device. Such a system with the basic capabilities of reading, writing, erasing, storing, comparing and branching with respect to patterns is a necessary and sufficient condition to do thinking:

COMPUTERS AS AIDS IN DESIGNING

One of the major challenges of today is to enhance the capability in design in order to be able to end up with equipment and products that achieve the desired performance at minimum cost. Optimization carries the lion's share of the technological effort. It finds expression through computer aided design, computer graphics, computer-aided production planning and control, numerical control, adaptive control variable mission manufacturing and ultimately the design of whole, integrated systems. It is well recognized that computer simulation is meaningful only if it is coupled with an intensive understanding of the basic processes that are involved. Projections based on models are increasingly subject to error if the operation times areextended or environments change because the parameters on which the formulas are based are liableto change, Considerable experience is needed to determine how much confidence may be reposed in the results obtained. The techniques under development are full of promise.

Any design process calls for many iterations before an acceptable solution is achieved. The large number of variables encountered, together with demanding performance and safety requirements characteristic of any advanced design, imply such complexity that every form of aid that has promise has to be explored and put to intelligent use. Computational methods enable the designer to launch on a comprehensive refinement of the project and, in the limit, produce a concept which is optimized to meet a given requirement. At first sight. it may appear that a full-fledged computerization of the design process will take away glamour and the scope for flair and innovation in design. This may happen if the process is totally mechanized. It will be wiser to retain the human designer as an integral part of the system under attack. There are a number of basic problems to be faced and solved-particularly in relation to the interface between machine and man.

Interactive techniques have a fascinating and vital role to play in the design tasks. It brings directly into the computational process the flexibility of the human brain with its capacity to think freely. The human designe has a lot of computational power at his finger tips. He is in a position to achieve an optimized design in a relatively short time. Very worthwhile results are achieved if the operator is an experienced design engineer. When the interactive facility is not available it becomes difficult to comprehend the technology bound up in the computer programms that are used.

Initially, interactive techniques were associated with analog computing wherein adjustments could be made to parameters or their effects shown in real-time in a visual display system. But analog computers are inflexible and are relevant only to a particular class of problems at any given time. It is possible to continue analog and digital systems in a hybrid form, but there are problems in this area, the most worrying one being due to the incornpiatble speeds of the two processes if a closed system is used. Interactive techniques based on digital computer components are the most useful. Visual displays are used to present relevant information to the designer who can then selectively modify it using an alphanumeric keyboard. The choice of the parameter to be modified may be done by code, by the use of a graticule over the screen of a videodisplay unit by means of a light pen placed directly on the display. Looking at the direct visual display the operator can use his discretion in obtaining a quick indication of the effect of a changed parameter cn a selected design input. The alternative is a lengthy analysis of the results obtained from a succession of batch programs till a satisfactory final picture emerges.

Interactive computer graphics has become a powerful tool in the armoury of todav's designer of advancsd systems. In the environment provided by it the designer gains rapport with the .computer and receives from it is direct, fast response. The two-way dialogue can be alpha-numeric or pictorial. The designer can, for instance, generate a geometric construction on the CRT using a light pen. The computer comprehends the geometry, makes calculations based on it and presents answer son a revised geometry. The designer may accept it or indicate the need for further changes. We -ee in this application the replacement of the designer's drawing board by a display console. The immediately of the visualization oft creative results has a profound psychological effect. The graphical display combines human judgment and data visualization possibilities with computer speed and accuracy. Stricking benefits flow from the use of stored information, three-dimensional visualization and, most cruciallv, faster geometric construction erasing, changing and recreation of different versions. The computer stores up the geometry-data created by the designer, and the production department has direct access to it and may use it at any convenient time. This helps to forsstalt any misrepresentation or the USeof outmoded data.

Computer graphics can be used to produce speedily two-dimensional project drawings. Repetitive or symmetrical entities do not have to be drawn each time; the computer will provide them as required. It will automatically calculate dimensions and display them on the CRT. More interestingly, computer graphics produces three-dimensional representations using surfaces, resulting in a view of components as seen in space and yielding accurate visualization in any desired direction. The underlying techniques permit rapid iteration until the designer perceives that everything fits. There is work in progress to incorporate polographic techniques into computer graphics, the goal being the direct fabrication of a piece from its integrated three-dimensional representation. Some day it may become possible to feed the customer's requirements to the computer and hence to the engineer for conceptual designs and making most trade-offs, using computer graphics. The technology and its applications are relatively new. It will take many iterations to master the conversion process. Coping with the flow of data from the computer will not only demand indepth understanding, planning skills and coordinated effort between engineering and manufacturing but also the adoption of new procedures for achieving efficient control of all the operations. There will be resistance to change. PeopIe brought up on conventional techniques will point to the high cost of camp uter systems and software development and question estimates of system reliability and capabilities. Yet the exacting demands of today's advanced systems design cannot be met except through the methodologies of computer-aided design and the exploitation of the wizardry of camp uter graphics.

CONCLUSION

The world was in many ways unprepared for the first wave of automation. We Seemto be over-prepared forthe second wave. Many tend to associate computers with powers that,· by the most optimistic forecasts, may not be realized till the middle of the next century. New achievements are taken for granted rather than taken note of with afeeling of heightended significance. When some of the activities that we now calssify as 'intelligent' are comp uterized, we will refine the use of the term and make them recede into the more subjective regions of human nature and experience. These activities will lose their glamour and will be relegated to the background as routine procedures. When ajob that previously required the sikll.] udgement and experience of humans is taken over successfully by a camp uter, we are no longer in a mood to admire these attributes in the machine.

We are not overawed by the fact that we co-exist with devices that can multiply figures a million times faster than we can. Our defence is that multiplying so fast is not essential for our survival. A similar rationale will be applied to underrate the fast is not essential for value of the fact that the computer has instant-access to a billion catalogued facts. We have access to that facts too, only not so fast; and the computer is merely a tool in this game. Says Hans Borliner: 'If a computer sometime in the future becomes a world chess champion, will we dismiss chess as an unimportant game? This may not happen this year or during the next five years but is possible by 1990.' He adds, 'I do believe that there aretasks that areSocomplex that the presentday design of computers would be quite out-classed by a human, now and possible always. Bur the number of such task is diminishing yearly and chess is on the endangered spceies list.'

At the other end of the spectrum, a characteristic of computer usage looms large-which is that it tempts us to leave out the intangibles or also make sweeping assumptions about them. This may not be a serious problem as long as we are able to keep computation in its place. There is no guarantee that we will do this. With computable problems, we will see ourselves making more headway than with non-computable problems. We may persuade ourselves to regard as important whatever is computable and to think of non-computable problems as non-problems. Mathematical models, which are hypotheses, may begin to be treated by us as social laws. The 'optimized planning that computers make possible so easily is full of pitfalls. Under a computed plan. deviations from predicted behaviour of individuals may begin to be looked upon as perverse and anti-social acts.

It is our duty to resist such tendendcies and reaffirm our fatih in the non-computability of human factors and the non-rational base of our value system. If we are successful, we will be clear as to where we draw the line in giving scope to computers in policymaking. The safeguards will be procedural rather than a matter of fixed code. Even high-level use of the computer should be challenged on principle-not from an anti-technological standpoint but simply to make certain that the quality of the data collected, the~erception of the goals to be achieved and the assumptions. made about the models are critically examined and, where deficiencies and grounds for controversy exist, these are fully debated. Seen in this light, computerization can have a salutary effect. It will compel us to consider our motives more explicitly than before; and remind us of the lacunae in our knowledge and the limits of our rationality. Above all, by relieving us from mental drudgery, it will give us time to think about the non-computable facts of life.

The computer is not just a productivity engine. It is wall on its way to becoming a responsive personal companion to ordinary people, at home or in their work-places. Advances in micro electronics make information systems both affordable and sophisticated enough for manyapplications. The underlying challenge in putting computers to use is just not technical. It lies in matching the broad spectrum of the new technologies to the service of the informational, educational and cultural needs of people constituting contemporary society.

Prof Herbert Simon utters this note of caution and advice: 'Scarcity is still a fundamental aspect of human condition. If we need to increase productivity, computer usage is only one of the ways we approach it. It is necessary to improve the human-machine interface through human-facts 'engineering as a way of forestalling alienation in automated or computerized jobs. Not enough human engineering is being done in present day designs. We can do something about this by asking what the human characteristics are in the environments that we are building with our new equipment:

In the task of building up genuinely useful systems, we should consciously follow an evolutionary, mancentred approach using appropriate computing aids. Computer software by itself will not take us to the desired goal. Human attempts to bring order and structure and meaning into all the information that we can lay our hands on is of prime importance. Machine aids should be used diligently to reinforce the human processes.

Says Lewis Thomas: 'Ambiguity is an indispensable element in all matters of real value. For meaning to come through there hasto be a vague senseof strangeness and askewness, When, for instance, a bee is trackinq sugar by polarized light, observing the sun as though consulting its watch, it does not veer away to discover an exciting marvel of a flower. Only the human mind IS designed to work this way in the presence of locked-on formantions,straying from each point, in a hunt for a better, different point.' An analogy may be seen between the bee in this imagery and the computer which cannot veer away from locked-on information.

Semuel Butler has given this dictum: 'Life will always remain a pattern in which we will be obliged to draw workable conclusions from insufficient data'. Machines cannot work from insufficient data; but man can.

John Gardner says, 'L ife will eternally be a struggle between mans' potentials and the hard situations in which he will find himself every now and then: We may conclude from this that neither man nor machine, in isolation can find answers to the complex and challenging problems of today. There is human work to be done all down the line with the aid of tools that are invented and made available to potential beneficianies from time to time. It is in our interest to fully participate in the intellectual revolution triggered by the advent of the electronic computer.

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Management of Change — a Philosophical Perspective

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INTRODUCTION

At the outset, I must express my grateful thanks to the Council of the Institution for inviting me to deliver this Memorial Lecture bearing the name of an illustrious person whose concern for humanity was well known. Great men live in the culture of a land through their ideas and contributions, though their physical frames have disappeared from the earth. Ideas and actions are more potent than the individuals who were their sources. They shape, guide and control the stream of society's consciousness. Those who recognize this and strive to perpetuate the memory of such great individuals must be congratulated for the service they are rendering through such actions. It is a privilege to join them and pay my tribute to the great.

I have chosen the title 'Management of Change — A Philosophical Perspective' for this lecture. I do not think I need to explain the reasons for this choice as we are everyday witness to continuous changes in our environment.

THE SCENE

The character of the present age is change. When we stand and observe, there is movement around and everywhere. In all walks of life we are experiencing change. Large number of technological innovations have contributed to enormous industrial growth. This has brought about a qualitative change in the way of life in many countries. Science and technology are advancing very rapidly. Instant communication, high speed travel are the order of the day. In a way, the 'instant' culture is on.

Incidents occur and spread fast. A minor incident in some part of the globe has the potential to amplify into a major conflict blowing upto near world-size dimensions. Be it an insult to a lady in a remote village, in a distant country or a skirmish between two border posts, it is forcing the attention of world bodies or organizations much larger than the incident configuration. Philosophically this means that a smali deviation from an accepted norm is amplifying to global sizes.

This is an age of planetary civilization with information being pervasive with large networks of communication and media. Systems which were nuclear have now enlarged into large and open systems. Intense inter-dependence and rich connectivity characterize them. They are complex and are characterized by change, feedback and level hierarchy. Therefore they are cybernetic. Understanding, structuring and coping with such complexity are the major aspects of managing these systems.

Today, it is typical of social institutions that the mean interval between shocks to them is shorter than the relaxation times required to adjust to the shocks. Consequently,· the institutions will either go into a state of continuous oscillations or plunge into the terminal condition of death due to the enormous amplification of the disturbance. Pollticians, intellectuals and other strong vested interest groups, whose role in society is to steer the institution out of the situation, adopt one of the following basic stances in the face of the crises. They either ignore the cybernetic facts and pretend that the oscillations are due to some dirty, wicked or cruel cause which can be stamped out, or 'organize some kind of a revolution with out allowingany redesigning of the faulty instruments of the government.

In most countries, the government is entering into the lives of the people in a big way; perhaps even more than what a monarchy normally expects to do. In the name of being representative or in the name of saving the people from . wrong forces, either way the government is taking over many of the functions and instruments that control the behaviour of society. Either way, small groups are controlling large societies. This is reflected in an isomorphic fashion at every hierarchical level of social governance.

The basic features of the existing societal scene can be summarised in breief as follows:

(i) The environments are becoming increasingly turbulent. In a sense they are assuming the quality and character of a crisis.

(ii) Ideas are moving far ahead of behaviour with the result that every action is finding a philosophical justification. Science and technology are developing exponentially and impacting society without corresponding adjustments in social behaviour.
(iii) A large lumpen group of people energized and stimulated by unscrupulous logics and desires are trying to hold society in its grip.
(iv) The present organizational forms and the aspirations and needs which they are exoected to represent seem to be incompatible and-in disharmony. Philosophically the vibration and form are at variance.

THE LOGIC AND PROCESS

Can We Discover the Process and Logic in the Situation?

Some basic things can be stated without much discussion that society is a large living organism with a mind and consciousness of its own; that it has a set of objectives which it wants to realize by its own processes; that it is an ideal seeking system willing to change its objectives, while on the path of growth to achieve its ideal; that it is open and there is a constant mopping of the external system on it leading to continous changes of state almost to the extent of non-equilibrium; that society experiences non-proportional growth patterns; and that the process of growth is symbiotic and not confrontational or survivalistic.

What are the characteristics of this large system and its complexity? What does it require to understand it? Will the normal known instruments of reason and logic be sufficient to unravel the complexity? What is the state of society in scientific and philosophical terms? If change is occurring what is the law of change? What is the form into which it will change? Can we consciously guide or force the change leading to normative patterns? These are some of the questions that need some answers if one is to get even a feel of the problem.

The possibility cannot be denied, according to K B de Greene, that humanity is fast approaching its cognitive limits as a biological entity and many features of society may simply be beyond human understanding and knowledge. However, researchers are devising new logical frameworks to understand these large systems. Till now dialectics of Kant, Hegel and Marx have played considerable role in the philosophical approaches to knowledge., In this approach one looks for sources of conflict, the driving forces and the sequence of thesis, antithesis and synthesis. Recently, in 1982, a new approach, called trialectics, has been propounded by Ichzo. This has the following sequence of steps: (i) Search for the relatively stable phenomena and transitions between them; (ii) (a) Identify for each component of the process the attractive variables (those aspects of the environment to, which the object responds), (b) Identify the active variables (those aspects of the object which determine the susceptibility to the attractive), (c) Determine the result (the aspects of behaviour which are to be explained), and (d) Search for the function which determines the result; (iii) Search for the cycles and loops in the process; and (iv) Search for a hierarchy of levels which allow phenomena to be classified with respect to energy, range and impact. In a complex situation where simple cause and effect relationships are not easy to identify one may have to adopt the latter logic to unravel the problem.

There are, according to researchers, several kinds of complexity, organiied simplicity, disorganized complexity and organized complexity. While the first two can be tackled by the available methods, there are as yet no methods to deal with the last. Unfortunately, most of the societal systems belong to this category. General systems theory and cybernetics however, seem to have the potential and capability to give an opening to the resolution of these problems.

A system must have a minimum complexity to be viable and cybernetic. Such systems have their own characteristic physiology, ecology, genetics and patholbgy. They have a tremendous homeosta.tic ability. They are open. Consequently, they have rich internal connectivity add external impacts to contend with. While they are flexible they also have a tendency to destabilize at simple provocations. General system theory recognizes a clear tendency of such systems to self-organize and self-adapt to environment. Also it recognizes the existence of an objective(s) towards which they move.

One of the basic difficulties in the understanding of a social system is the derermination or identification of its goal or objective. Much greater is the difficulty to trace the path of the movement towards this goal or objective. Largeness and complexity are primarily responsible for this situation. Many attempts to understand the situation have fal\en through due to methodological difficulties. Therefore, there is a feeling that humanity is fast approaching its cognitive limits as a biologica1 entity. But the search for solutions is continuing.

We hypothesized earlier that large societal systems are ideal seeking. An ideals seeking system, according to Russel Ackoff, is a purposeful system which can choose between objectives in the journey towards this ideal. An objective is a preferred outcome over a large period of time. To realize this it may change the goals, during the process since a goal is a preferred outcome within a short specified period of time. According to Ackoff, an ideal seekin.g system is Truthful, Good and Beautiful which is similar to the Indian concepts of Satyam Sivam Sundaram.

General systems theory (GST) is the result of an attempt to generate theories which help the understanding of similar systems in different areas and disciplines. It is the thesis of GST that biology, natural sciences, mathematics, social systems, etc have a lot of common features. It arranges systems into levels of interactive hierarchies which cannot be reduced to sub-systems without altering their patterns. Feedback is one of the central concepts of GST and also cybernetics. Through this a system keeps itself informed of its progress towards its goal(s) or objectives. Another central thought on GST is the tendency of a system to self-organize Into more complex levels of organization.

Of this complexity H A Simon lists four aspects:

(i) The frequency with which complexity takes the form of hierarchy;
(ii) The relation between the structure of a complex system and the time required for it to emerge through evolutionary process;
(iii) The dynamic properties of hierarchically organized systems and how they can be decomposed into sub-systems in order to analyze their behaviour; and
(iv) The relation of complex systems and their behaviour.

Now, it is fairly evident that a new level of understanding is required for large and complex systems. A simple statement can be: That Jarge systems require large/high levels of understanding/comprehension by those who manage them. What is the large level? The mind of man for all its marvels is limited in its range of perceptions, the five senses and the antahkarana, the internal instrument according to Indian yoga. It is however a marvel that this limited machanism or instrument produces remarkably adaptive behaviour under normal circumstances. Normal circumstances are slow paced but our present circumstances are very fast paced. We need, therefore, a fundamentally different theory to manage this change. One can by now see that the concerned areas are psychology of learning, perception linguistics, epistemology and information. The linking logic is provided by cybernetics.

Erich Jantsch has identified levels of learning, understanding and comprehension relevant to the various hierarchical complexity. The present situation can be analyzed as a non-equilibrium situation in a highly developed science and technology condition. The question arises: Presently is the system in transit or transition? A transit condition is a point on a smooth curve of movement or evolution. Consequently a linear or non-linear extrapolation of determinants of the system is adequate to forecast the configuration in the coming decades. A transit condition is essentially in equilibrium and incremental deviations need not be normally amplifying. The feedback will be generally negative or mildly positive. The situation therefore is of usual kind with no great surprises. But is our present social condition like this? In view of the observed or exhibited highly positive, deviation amplifying feedback the nature and condition of the system at the present time cannot be classified as simple equilibrium-transit but as non-equilibrium-transition condition. This calls for a new approach to understanding and prognosis.

Approaching the problem in the above macrosense, can we look for an analogous situation in any comparable system like a sub-human biological system? The answer is yes.

The present social situation is similar to dissipative structures of Prigogine. Dissipative structures can be considered as giant fluctuations. As such they are determined by stochastic processes and not by deterministic processes. The equations may 'reveal' the nucleation of a new dissipative structure. For this the ordering principle is the 'order through fluctuations.' In the non-equilibrium condition, the system becomes dissipative above a certain thermodynamic threshold and enters into a high degree of interaction with the environment. This behaviour is called 'evolutionary feedback.' As dissipation increases, the class of fluctuations leading to instabilities is widened and new functions rise. New functions require new forms. This is in a way supported by sociologists who feel that society has limited power of integration. If the perturbation exceeds that power of integration the social system is either destroyed or gives way to a new organization. We seem to be in this condition in an age of perpetually transforming non-stationary cultures.

Complexity is related to the perceptual level. As understanding increases complexity reduces. The level of conciousness at which humanity operates is therefore relevant. This implies a knowledge of the process and law of change and the form into which evolution leads. Some statements can be made in this connection about the evolutionary processes and form.

Generally, process and structure, growth and form are related. While growth is determined by form, form limits growth. Purposeful systems, according to Jantsch, seem to follow two basic rules:

(i) The structure remains flexible to allow emergent changes during the process; and
(ii) They are continuously conscious of their selfbounding nature and the processes of change are identified and followed in relation to this consciousness.

To provide room for this flexibility, certain nonequilibrium conditions are generally allowed to exist. This characteristic takes the social systems, according to Milan Zeleny, out of simple operations research and econometric formulations. Further conflict is seen as a seed and source of new forms. Where conflict is endemic as in our present situation, it has to be interpreted as a non-equilibrium condition at the boundary of stability space.

THE LEARNING

What is the learning modality in such a framework of freedom and flexibility? Jantsch feels that such a situation demands a close linkage between microcosmos, the human and the macrocosmos, the organization or the environment. The Indian philosophy of Atman within and Brahman without which an integral relationship between the two fits this concept. 'Order through fluctuations' also requires a similar relationship with the environment of an open system. The environment maps on to the configuration of the existing system and the new form will reflect the characteristics of the environment. Maruyama calls this Atmen-Psremstmen paradigm. The learning mode consequently is the super conscious linking man and culture. Two important points emerge:

(i) That systems reflect culture of the land and hence the necessity for the management to be culture specific; and
(ii) That social systems have the capability of self-transcendence and not simply selfadaptation.

Another interesting deduction is that the open systems and the configuration environment together contain the solution or throw up the new form. This is similar to the principle of involution and evolution or descent and ascent propounded by Aurobindo. According to this, evolution is the unfolding of energy and form at many levels and self-transcendent systems are the meansto ensure continuity of this evolution.

Another perspective is also useful in getting a better feeling for the learning processes. We have seen that social systems can be treated as dissipative structures. These tend to switch to new dynamic regimes involving structural changes in times of crisis when the energy exchange process tends to become stifled. Imbalance between internal and external learning processes arise implying a certain tendency to change, leading to retention of old structures. This, in turn, leads to an obstruction to the emergence of new forms and structures, even though it may be for a short period. However, evolutionary processes cannot be contained indefinitely by external management. Life processes and social forces will eventually breakthrough the artificial barriers and boundaries. The structures start breaking loose and yielding, becoming flexible and facilitating changes. During this process, the whole scenario looks chaotic. On one side the evolutionary self-reflection moves to higher levels and changes at lower levels tend to occur at higher frequencies. In our present context, one can note that technological and physical changes are occurring very fast, almost at break-neck speed, while social response or change is occurring at aslower pace. Associated cultural changes are almost invisibly slow. Mesarovic says that such acceleration at lower levels reflects the emergence of a control hierarchy. This means that man has to correlate with higher levels of conciousness while acting to introduce changes at lower levels of control hierarchy which come within his ambit and grasp. His intellectual and power and the thrust of his activities are controlled by higher level cultural thinking beyond his conscious understanding. In clear terms, at the present times, man will be forced to adopt an idealist view of life to meet the present challenges of change.

Now, the law of change. This is not easy to discover due to the large number of parameters that are involved. One can only trace some likely characteristics of the new form at some given phases of this change. It is like dividing the curve of change into linear bits and the form into finite elements of the mosaic.

One point can be clearly made that the process will be to reduce complexity and nucleate a new form around simple forms at a higher level of understanding. Since process and structure are highly integrated in social systems, they can be characterized as autopoietic systems. Autopoietic means self-creation and covers all living organisms and their organizations from macromolecular to differentiated, self-perpetuating animal and human species and their organizations. An autopoietic organization can be defined as a network of interrelated components producing processes such that the components recursively generate the same network of processes which produced them, the network of processes achieving identifiable unity (Milan Zeleny).

Human beings live their lives through human systems and try to shape them through their individual aspirations, goals, norms, values and actions. But the resulting set of system purposes can turn out to be quite different and independent of the individual ones. Social systems are essentially ideal seeking and consequently aim at being good, beautiful and truthful. Since the indications for the new humans are that they should adopt an idealist view of life, the possibility is that the process of change will be such as to bring harmony between individual and social goals. Since the agencies of man's correlation with environment are religion, science and art, the learning and logic modalities behind these should govern the processes for emerging successive dominant patterns of socio-cultural organizations. They should govern the development of the dominant modes in the for mulation of concepts, theories and intellectual methods. The new society should be based on emerging logics. According to Maruyama, these are transepistemological and have the ability to transcend their own loqic and emerging logic is mutualistic. heterogenistic, symbiotic, interactionist, qualitative, relational, and contextual replacing the traditional uniformistic competitive, hierarchical, quantitative, classificational and atomistic logics. The process is change amplifying and mutual interactive in goal generation. Similar conditions may produce dissimilar results if there is a deviation amplifying mutual causal link. The basic principle of change, therefore, is diversification, heterogeneity and symbiotization. What survives is not the strongest but the most symbiotic. We seem to be in a state of perpetually non-stationary cultures.

According to Jantsch and Zeleny, the above lead to some interesting conclusions about human society and man of the future. There seems to be a strong necessity to replace the present concepts of competition technocratism, material efficiency, hierarchical leadership, majority rule by homogeneity - with nature, cultivation of mind, spirituality r non-hierarchical mutualism and pluralism. They form the components of any law and/or process which governs change and the future society. Self-transcendence becomes an inherent principle of evolution and man is not a mere member of systems and meta systems. He lives simultaneously at all levels of consciousness, a concept which is similar to the theory of five koshas of Indian philosophy and theory of yoga. The society in which he lives and shapes is governed by ideals which may not be exactly Ii e his personal objectives, an echo of the Buddhistic chant Buddham Saranam Gachchami, Sangham Saranam Gachchami, Dhramam Saranam Gachchami .

In the above context, the projections made by Alvin Tottler in his 'Third Wave' become a minor, incremental, linear step in the process reflecting a simple welfare society or a modified extension of it in a spohisticated technological environment.

THE FORM

Now, can we say something definitive about the form of the future society or organizations?

It is difficult to answer this question specifically. A part of the answer is found in the earlier attempt to discover the process. The instabilities, the changes, the transitions and crises in the process are like vibrations in a system. It is well known that vibration and form are related. The science of morphogenetics deals with the evolution of form or order from chaos. The processes in this are similar to the Vedic concept of evolution of form out of a primordial sound Om or Vak. According to Tantra, our speech is the grossest form of Vak. Except saying that all these sounds and vibrations lead to or evolve into concrete forms as sound crystallizing into words, the form, in the case of society, is not easy to delineate with precision.

An autopoietic model also has similar difficulty. It may not be able to design or plan a future society or organization but can discover rules of antopoiesis or strategy for order formation. These rules are essentially self-evolved, self-maintained and controlled according to the context of the situation.

Thus, society and its future forms have the same characteristics as /shwara, the finite Brahman of the Indian philosophical thought. He can be described by characteristics and qualities and not definitive forms.

THE MANAGEMENT

Now we touch the title. How to manage this elusive but massive transition or change?

Management can be defined as the act or set of acts or processes of deploying, physical, material, intellectual and other resources to serve a purpose. This involves decisions, decision-makers, decision styles, decision situations, decision frameworks, decision processes and decision rules. The task of management is to stimulate and nurture a vigorous network of the above. A decision is an action proposed to be implemented for changing a situation.

Most of these has been dealt with alre-ady. In a way, we have said that the character of complexity is central, as articulated by Stafford Beer, to all our decision paradigms and todav's management is decision under complexity. Without much contradiction, we can say with Beer, that complexity is one of the main underlying causes of poor performance of many of our institutions including government. The thrust of management is to generate strategies which have a multiplier effect overcoming the resource and other constraints to stimulate the emergence of naturally dominant progressive cultures. These are linked with knowledge evolution, called 'noetic evolution: which is characterized by the emergence of new dominant modes of concepts, ideas and cultures. These are evidently guided by the laws, logics and processes of social evolution explained earlier. These notions apply to the management of man-designed organizations as well since they are fast acquiring the character of living organisms and systems. Management of these should consciously make flexibility in form and structure fundamental to the management of change and have a purposeful alignment with the process of emergence as a goal of management. To say more at this stage requires considerable research into the details of management.

INDIA THE ANCIENT LAND

What is the macro decision in our case? What does this ancient land and culture mean in this context? India, the mother has nurtured her people as contemplative children and turned them towards external truths and profound meanings of life. Now these intuitive and experiential statements of truth have degenerated into mentallized statements, intellectual justifications, and fruitless hair splittings leaving the society cold and confused. While the moorings are still strong, the once successful attempts to translate the profound thoughts and intuitions into social structures, remained stunted after a time. The powerful knowledge, truth seeking movements have diffused into confusion and the material aspects did not get the right perspective and thrust. History seems to have reserved this to the western nations whose efforts to develop the understanding of nature and unravelling the secrets have reached unprecedent peaks of achievement. They have harnessed these discoveries to increasing human standard of living.

Being an open society, India is not receiving the impact of this great scientific, industrial and technological revolution. The achievement of harmony of the two great movements-the spiritual and the material scientific- is now in the offing all the world over setting the trend for the next century or the next era of history of mankind. This, to my mind, is the significance of the motto and meaning of the present movement of India's process of change and emergence into the comity of nations. Our responsibility is to manage this change with full cognition of its material and spiritual components. While this is the macro grand panorama of the change, the elements of this have to be understood carefully to climb the several steps along the- ladder to this scenario of synthesis. Following the principle of non-proportional growth, if our culture stands on the strong leg of spirituality, the present has to strengthen this by its material counterpart, without loosing the strong leg due to structural erection stresses. The synthesis must be symbolic. This is possible since the mind of India, as Romesh Thapar articulates, has remarkable dimensions. It is open, profoundly cogitative, flexible and strongly mediative. However, such a mind is now somehow gripped in confusion (Romesh Thapar). We have to lift it out through idealistic understanding and strong leadership.

THE MANAGER

The key factor in management process is the manager. In India management by crises has become normal and we can congratulate ourselves that we have done well. This requires fast and heuristic judgments. This was and is possible because of the strong intuitive culture of this ancient land.

However, in a continuously fast changing scenario, maintaining this ability and still maintaining congruence between organization and environment is very difficult but is one of most important functions of management and the manager.

What kind of manager can achieve this? From the above discussion, one can easily see that we are at a stage at which human systems are in transition. As stated, human systems are autopoetic, ie, selfrenewing, self-repairing and also self-transcending. If a manager is to gear up his management to achieve the institutional objectives of which self-renewal is one, he should act more like a catalyst than as a designer of an organization (Zelany). He should adopt an idealist view of life and deal with problems from a higher level of consciousness. In the language of Gita: Adhyatma Chetasah.

According to Zelany, alignment with the process of emergence implies giving up some presently held beliefs, viz,

(i) That human progress is synonymous with economic growth-and increasing consumption;
(ii) That it is the destiny of mankind to conquer nature; and
(iii) That economic, efficient and scientific reductionism are most trustworthy approaches to fulfilment of goals.

EPILOGUE

We seem to be on the threshold of a new, golden era characterized not by the mere material but a great synthesis of spiritual and material which is a confirmation of the faith of the great Rishis, Yogis, saints and savants of not only India but the whole world. The managers and managements have to live upto these expectations. Then the dreams of those who have gone by and those who are to come will be realized and we shall be blessed for playing our part.

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Service to Society

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Let us define 'serviceto society' as it has different meanings to different people. Beforc this, let us recollect the basic fundamentals of life—known to everyone—yet we tend to forget.

A person, when he enters this world, comes alone. Similarly, when he or she leaves the world, goes alone. Soul is indestructible and everything material is left behind. No one knows from where the soul comes and where it goes back.

A child enters this world as a maleor. female. Out of all species, human being is the only one with brain having potential to develop, to think, to control and to act. The actual development depends on the environment and circumstances under which the child enters and grows in this difficult but beautiful world. Religion, language, nationality, morals, customs, narrow feelings of region, caste and creed are our own creations, given to the child as gifts of good and bad environment.

Society can have a limited or unlimited meaning. Society can be a group of few persons belonging to same religion, language, nationality, region, caste, culture, custom, class, etc working together or in different avocations or in one trade or living as members of — a large or a small family, etc. It has unlimited meaning when you encompass the whole universe. The meaning of society is thus unlimited or limited and restrictive depending on one's thinking, attitude, brain and mind's education and development. Human instinct starts turning into animal instinct when one starts contracting one's sphere of thinking and influence. The worst results occur when one draws a complete shell around himself turning into madness—a totally and literally mental case worse than even an animal.

Service to society, how big or how small, depends on one's thinking, attitude and level of mind's development. World epics likethe Ramayana and Geeta are universal gifts to society by the great Rishis Tulsidas and Balmiki. Many other philosophies and messages such as by Tiruvalluvar, Buddha, Mahavir or by Guru Nanak, Ramakrishna Paramahamsa, Swami Vivekananda Gandhi and Radhakrishnan have universal acceptance and application. They may belong to or have originated from Hindu faith but Hinduism seems wider than religion. It is a way of life with a capacity to create and/or absorb any number of faiths and beliefs propagated by other faiths or religions. There are many other religious epics having larger following all over the world but yet tend to become restrictive. Their followers restrict them to those who have faith in a particular way of life and thinking. God's message of love and service is universal but we compartmentalize it and interpret and preach it with competitive spirit to suit our own interests and requirements. This is where friction starts and service to one community and group becomes disservice to other sections of society. This is realized only by some of us as individuals only when we grow, learn by personal experience and are about to leave this world.

Science in comparison is less restrictive and has no barriers. Works of Newton, Eienstein, Ramanujam and many others have universal Growth of scientific application. knowledge and application is unlimited in any field you pick up. But here also, in the name of 'service to society' as we comprehend, we start directing it to destructive purposes instead of service to human society. Money of the material world becomes the controller and animal instinct gets the upper hand. Money spent on arms of destruction, if diverted to constructive channels, can alleviate and eliminate the sufferings of entire humanity.

All this goes in the name of society: freedom, nationalism, systems, ways of life and for their protection. But for whom? Suspicion from each other? No one can however destroy universal gospels. Faiths, systems and people come and go but cultures and civilizations based on universalism cannot be destroyed. History reveals that Indian culture and civilization have been constantly under attack, both external and internal, even though they never believed in materialism and never spent money and created arms of destruction for offence. As a result, the country and its people have suffered again and again but in the end, because of our message of universal brotherhood, we have survived. If world has not to face total destruction, countries like India with their universal messages must survive. The weak points of universalism are far out-weighed ultimately by the eternal and permanancy of soul's immortality. There are immeasurable sufferings to people if a country and society remain weak giving temptation to strangers and the unscrupulous to attack, plunder and exploit. There are many such instances in history and history repeats itself again and again as basic instincts of human beings remain unchanged.

In cultural fields, works of Rabindranath Tagore, Shakespeare and many others are immortal. For their wider application, however, meaning of society needs to be correctly understood and broadened according to our attitude. Language, customs, food habits and cultural affinities which provide close personal contacts and communication perhaps provide the strongest links in any society.

Politics provide an importantand one of the best opportunities for serving society. Thelinkscanbe strengthened, moderated or weakened by the game of politics. There is always good and bad in society dividing friends, foes and ‘so on. Chanakya Neeti provides insight as to how to handle foes and problems in society and have smooth sailing and maintain proper within inter-relationship and outside the country. If statesmanship can be mixed with politics, the boundaries of states get broadened and narrow feelings and thinking ‘get a back seat.

Look at the way Mahatma Gandhi and Pandit Jawahar Lal Nehru gained independence for India. No bitterness or rancour was left and, what is more, it paved the way for independence of so many other countries subjugated and exploited for ages by foreigners. Statesmanship of Pandit Nehru also laid the foundation for the non-aligned world, basically to educate and to bring together people who can keep away from the game of destroying each other and exploiting the poor, illiterate and have-nots. Yet, at the time of India’s partition, Sardar Patel’s presence was vitally important for India’s build-up from a heterogeneous mass of confusion and chaos into a single integrated sovereign country. One can stand up and speak with confidence and reach out and help others only if his base is stable and has the needed strength and energy.

Man is basically a social animal but his animal instinct, ifnot controlled, developed and channelized properly can wreak havoc. We all need company and no one can live without that. A king with all the riches but locked in a most beautiful and luxurious palace will get fed up in a short time if not given a chance to show his strength and powers to his subjects and foreigners. Politicians make or mar a country. If the riches and the power are placed in wrong hands, the result can be destruction and sufferings. Read history and any number of examples can be found for wars, battles, fights and massacres perpetrated on humanity by ambitions for the whims and fancies of a few individual perverse minds. This happens when animal instinct of dominating and exploiting the weak takes upperhand in a human being. So much is being done and is said to be done today in this manner in the name of justice and service to the needy, poor, weak, exploited backward, illiterate, sufferers and so on. But look at the type of service actually rendered if it is tied with strings and selfish interest.

We all serve—the government, the public sector, the private sector, organized and unorganized. Unless the service is selfless and devoted and open to all humanity, without any strings attached and with no returns desired, it is not service in the true sense. Even in a restricted sense, service to a group or section of society must be above self, implying sincerity of purpose, devotion, love, affection and humane feelings to be useful to the group or section of society as a whole. Let our service in day-to-day work and life at least satisfy this criterion of ‘restricted service’ and give in return what we are supposed to give. We are maintained by organizations, institutions and society, our nation and country and what do we give in return. We want everyone else to be upright, fair and just but we are not prepared to accept the same principle for ourselves. Truth and righteousness are all for others. They become bitter and difficult to swallow when it comes to us. Instead of being served, society is getting burdened with parasites and services are getting inefficient and unhelpful due to lack of sincerity, malpractices and deliberate acts of indifference.

Men possess different kinds of might: some have wealth, some have health, some intelligence and some can generate wealth. Whatever be it, it must be used for betterment of self and the people around. Use of these strengths to the cause of society will mean service to society and satisfaction to the man concerned. If these sources of strength are not harnessed properly, these will deteriorate and will become a loss to the person.

Thinking of high ideals of service to humanity is neither possible nor practicable for every man. Achieving that stage is reaching the fountainhead of God—the indestructible nature. In the practical form it is not possible for ordinary human beings to completely sacrifice all their needs nor that is desired also. What is the use of going all over the world and offering services when people next door crave for help. Charity and service, therefore, have to begin from one’s own home. What is needed is a sense of balance, a proper blend, so that eHorts and resources of all human beings could be pooled for the benefit of entire humanity. One of the basic lacunae in Indian philosophy has been to ignore this aspect. While Indian civilization has stood like a rock and withstood several onslaughts, yet many occurrences resulting in immeasurable suffering to people in the past could have been minimized if setting up and strengthening of organizations and institutions was also linked with this philosophy. As individuals we are on the top, but what happens to us as a group, as an institutionor as a nation? We are facing similar serious problems internal and external again 40 years after independence. We must understand that while idealism is the ultimate goal for self and individual’s Nirvana (salvation), for the protection and preservation of society, we must keep a constant watch on the weaker and yet most powerful side of human mind-—the animal instinct. Due to lack of recognition and practice of this we have basic contradictions in our society. What we preach in practical life appears to be exception and not the rule. May be the reasons are different; perhaps over-population leading too many people but too few goods in turn, giving rise to economic imbalances, and eruptions in the form of caste, creed, language and regional quarrels. But the fact is that no country has such a rich heritage of philosophy; cultural and civilized life as India and yet today what we see is entirely a different picture. Due to removal of communication barriers, contradictions appear to be more glaring.

What is our child and female care? We give the highest place to the female, the procreator of this universe—Mother. Yet, see our attitudes to girls!' As a country and nation, why should there be differentiation in types and standards of education. Children from low or high, poor or rich have the same potential to develop.

Now let us see what we can do for ourselves, our society, our country. Countries like India must survive if world has not to face destruction. No country can provide so much freedom to an individual. India should be so strong that no one can dare to enslave us and if anyone tries, he gets the right lesson. Our strength has not to be merely in terms of armaments and industry but we must be strong mentally, physically, economically, spiritually, and culturally. India's strength in the past also had never been used for enslaving others. Our people have gone to other countries either for work or with a message of love and service. Whenever we had been strong we had control over our animal instinct but when we became weak, it became the other way round. This follows also from our philosophy.

How can we serve society and the country? Let me talk at two planes. Those who should or have a perspective and can do service to many and for much longer span of time by virtue of their position, wealth, political, spiritual, mental development and those who cannot rise to that stature easily. Both need to be tapped, amalgamated and a balance created. For development of the whole, each small of part has to be attended to. Strength a chain is determined by the weakest link. To make India strong, theretore, we must understand that each and every village and unit, big or small alike, has to be made strong. India is a diverse and multicultural country and its strength lies in its diversity.

At a higher plane let us think of long-term measures. An individual's life is short but the country lives for ever. The need is for balancing of population, equal opportunities, good education, adequate medical care, facilities for sports, cultural development, communication, hygiene, clean water supply, housing, food and healthy environment, building up of infrastructure for agricultural, scientific and industrial base and investments in constructive activities instead of following populist policies. A large proportion of our expenditure in Government and in other sectors go towards establishment charges and thus to cater to the requirements of hardly 10%- 15% of the population. Why should not we enforce control on population, gprevent pollution of air and water and destruction of trees and regulate their cyclic growth? Why should we not make judicious development and use of energy and other natural resources. The required legislation and its faithful and pragmatic enforcement are needed to ensure in-built for safeguards imbalances in development. Restraint in political, religious, language and regional fields is needed and all energies need to be channelized to build up the moral character and a national spirit. Human resource is our largest asset if it is properly harnessed otherwise it is a liability. Both at higher and lower planes we can train, develop and use it for the benefit of individuals and society. Each one of us can, in the process of building ourselves, which we must do, keep group, regional, social and national interests in view. Let our energies not work at cross purposes but work in a co-ordinated direction. Two ones (individuals) can be two and zero also. But it can be 11 if they get totally and emotionally attached and merged for pursuit of a common purpose. With 7oo million people, if we can set a common goal with a common purpose, we can do wonders.

What can we do in our own field, ie, public sector, mining and energy areas. We control the largest investments. Major efforts of fund collections and aid programmes are being arranged to raise the country's standards in every respect. What, however, is the result? Gains are not reaching all. Growth in population is outstripping the gains of development and industrialization. Poor are becoming poorer as only a small section of socicty, with power to spend and purchase, is deriving the benefits. In theenergy sector, we provide the basic energy resource and industrial and domestic raw material input. Are we proceeding in the way that society gets the benefit? Rural areas still live on wood, cow-dung and other resources for fuel. How much time they spend in collecting this material and, if we measure the time spent in this effort, it is much more costlier than other forms of commercial energy.

Between mining, hydel power and forest sectors, we perhaps cover almost the entire tribal, backward and remotely living poor population of our country. How much money, energy and efforts are we spending in these areas? Yet forests are getting denuded creating serious environmental problems, Silting of rivers and floods year after year are the direct consequences, creating havoc for the poor rural population and serious longterm unstable conditions for the people and the country.

People living in remote mining and forest areas are the most backward and worst affected devoid of basic amenities and opportunities. Why do we need so many foreigners from all over the world to come, teach and educate us and provide medical and other needs of life in such vulnerable and sensitive areas? Do you get all this for the love of all over your country? History the world shows that these activities, though introduced in the form of alleviating human sufferings ultimately turn out to be the forerunner of so many problems including domination, slavery and sometimes seriously affecting the very base of society and the country, Why can't our own people spare some of their time and serve and help in developing their surrounding backward areas and people staying there? Why can't we gain their trust and confidence by service instead of alienating them? Vast resources are at our command and national policies provide for that. It is the missionary zeal, attitude, spirit and right mental approach which is needed in us and not merely the money.

Foreign help in whatever form, including education and medical, is generally not without strings. If you compare its teachings and philosophy with our rich past heritage, you can note the obvious flaws unsuited to our way of life. Why cann't this service by such agencies not come to solve our basic problems, if it is supposed to help us and is supposed to be without strings? Why some of them oppose family planning and control on unwanted ipfopulation? What right do we have to give birth and increase population we can't look after and bring up healthy children? Why not tackle the root of the problem? Why create and increase this burden, and then try to get credit by touching the fringe, by doling out borrowed charities on the unfortunate and helpless orphan and poor children? Why produce and throw them into the slums, gutters and make them a burden on the overburdened society if they can't be given care and proper development? The elp and aid in education and medicine, except in very few cases, is part of an organized service very much different from the ideals of the selfless service rendered by the Ramakrishna Mission. Admissions in such institutions are restrictive, selective, conditional and their services are well documented and catalogued. Politicians and the powerful who live on others' resources, take full advantage of such welfareservices and sometimes use them as tools even without their knowledge and willingness.

Idealism and practice are very much different and poles apart in today's materialistic world. Countries like India with its philosophy and unlimited freedom to individuals are always vulnerable to the influence of animal instinct further strengthened by gains of material and economic power. Look at South Africa and many other countries with political and administrative systems abhored in principle by the so-called free and democratic countries. Yet, in letter and spirit, their strength and, quite often, survival are dependent and inter-linked with progress and economic prosperity of the same. separatist and hated countries. Money power and animal: instinct playan important role even at the international scene.

For survival, development and strengthening of India we must develop and enforce certain national compulsions for inducing the required discipline of mind, national character and moral values. In spite of severe contradictions in our socicty, which are likely to continue, we must ensure that no one is permitted to preach and work against the nation's interests. In this, we must be ruthless, provide freedom but not for destroying the system, society, nation and the country which protects, develops and gives them the very freedom and individuality. We must not permit populist and short-cut selfish policies—be they in political, religious, business or any other field. The country, its communities, its philosophy and ideals are supreme and eternal. Jf the country survives, the people also live. Let us all serve and strive to uphold them and not act at cross purposes. Diversity, like in nature, is our strength. Let us concentrate, coordinate and direct all these diverse ideas, forces and energies to reach one common goal of strength, unity and prosperity of the nation.

We can make a start by doing our bit in the best possible way wherever we work by giving up the habit of picking holes in others. Like charity, let service also begin from our homes—by serving, working and doing things in a disciplined, sincere and dedicated manner. Let us do at least the work for what we are paid. This work though looks small can become great and praiseworthy if an enlightened mind gets enthused with the spirit and attitude of responsible citizenship. Let the Geeta's Karma theory guide us. The fruits of Karma will definitely come. We will reap what we sow and cultivate. Let this be our service to society. Our work culture, particularly our public service activities, must get infused with an enlightened and responsible citizenship and awareness of the humanistic aspect.

Vivekananda said: 'Only those live who live for others.' Let us serve and live for ever.

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Science and Spirituality: Their Overlap and Exclusive Domains

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Many would say that ours is an era of science and technology. Many would also add that science and technology, as opposed to social sciences and humanities, are tools of the evil. Science has intensified the terror of war, science has empowered evil tendencies in man, science has lend support to abuses of man and environment. On the other hand there is also a large positive side to science that cannot be denied. Science is a great force against poverty and disease. lt has brought instant worldwide communication. Tt has brought all of us together. Tt has taught us to think in terms of all humanity and banish pettiness. Tt is against self centered conceipte d tendencies. Our intellect has feasted on the purely scientific achievements of breath takingly wide understanding ranging from the minutest particle to the entire universe. The fascination and joy in understanding what distinguished the living from the non-living is incomparable. The adventure of the moon-landing is an eternal pride.

Consequently, undoubtedly ours is an era of science and technology. The intensification of the terrors of war and empowering the evil tendencies in man also has a positive aspect. It calls upon us to take an urgent and deep look at the basic causes for these and eliminate them. World has never before realized this need with the intensity and urgency that is now. Science has projected the evil within us on to a large screen so that we look at it with clarity and become fully aware of it and fully impressed about the need for a radical cure.

Unlike religion and politics science does not divide humanity. There is no Russian science, American Science, Black and Brown Science. There has never been wars with alignment based on science.

Man has needs, desires, ahd curiosity. These are the driving forces for the development of technology. Need for self preservation brought the hunting tools and farming techniques. This was the beginning of technology in human life. One next demanded better shelter and evolved techniques of making dwellings; demanded better protection from the vagaries of the wether and discovered cotton and then technique of making clothes, and so on. Today our demands and desires have brought us to the modern high technology. There is no end to the eve r new variety of desires. They keep us going in an endless persuit of inventions and new technologies. Curiosity to understand the breathtaking expanse of the phenomenal world is the fundamental driving force in the development of science. Science and technology have provided great momentum to the human society. However, we must find out where is it leading to. Or is it just going round and round. The answer to deeper questions on direction in technologically propelled society does not lie in the traditional futurology. It lies in sharper analysis of the nature of the fundamental driving forces behind technology. We ask, for example, what does a hungry man desire to achieve? Does he eat under the dictates of the hunger or does he eat to get rid of the hunger ? A man below the poverty line looks at hunger as a risk to survival. It brings worry and agony. He wants to get rid of hunger. A well to do man is not oppressed by the risk factor. He is at ease and recognizes the normal function of hunger. He is in a position to look at other aspects of hunger. He lets himself go along the dictates of this impulse and enjoys good eating. Can we look deeper into the workings of our mind to find out if their remains a lurking problem even after a good sumptuous feasting. There are those, and a vast majority of us belong to this class, who love good food and eating. They do not aspire to get rid of hunger, they aspire to enjoy good food and a good hunger immensely adds to the enjoyment of good food. But let us see if there are deeper levels to this question. We can clearly see that enjoyment is a function of mind. Let us ask, is it inseparably also dependent on the external objects of enjoyment ? The very emergence of this question is an advance. Normally it does not occur because of our pre-occupation with the difficulties in acquiring the objects of enjoy merit, When technology makes the acquirmg easy that stress is reduced and it allows for the emergence of subtler questions. Our needs and desires relate to external objects, and technology is at our service to reach out to these objects. It not only enables us to reach out to the objects, it also improves upon the objects in accordance to our fancy. In fact it goes further, it suggests new modes of enjoyment of new kinds of consumer goods. There arises a great interplay between our fancy and technological innovations to enrich our modes of enjoyment. One can completely loose oneself in this play for the entire life. One can also see through the play and find it inconsequential and fundamentally unsatisfying. When this happens we ·are in the overlaping domain of science and spirituality.

Man will al ways remain indebted to technology for survival and for growth. Man could not have won the battle of the survival of the fittest in the prehistoric forests without his technology. Today, in our country we would starve but for the great technological advancements in agriculture. Without the modem medicine it is doubtful if we could survive the spread of some of the virulent epidemics.

Technology has provided power into the expressions of service. Jt has served as an equalizer of economic disparities. What was available to only the elite yesterday is now mass-produced and is available to the entire population. Technology has a natural tendency to reach out to everyone. It fulfills not only individual desires but also social and collective desires. It fashions socio-economic revolutions. From the stage of grim risks of survival it takes us to a stage of comfortable confidence. And then it ushers into an interplay of fancy and consumerism.

Technology also provides power to the baser instincts of greed and dominance. This feeds into crime and war. It shakes our comfortable confidence from its roots. We begin to ask what is the inner makings of the humans ? Can it survive ? Or will it destroy itself ? Technology projects the fundamental questions of human existence and purpose in stark relief. The early victory of the pre-historic forest dwellers over his competitor animals could have lead to comp lacency and lithargy but the dichotomy of man's inner make-up has projected the fundamental questions in a demanding way. Those societies that have grown into affluence have to face the problems of crime, war and decay. Technology that helped in the fulfilment of small and large desires has also focussed on the essential conflicts within desires as such. Can we at this stage look ahead and examine if desires can ever be fulfilled. Our immediate response is that it can be fulfilled. But a deeper look on a wider canvas of cause and effect over larger duration of time reveals a different story. And the pace of this revealation is quickened through technological efficiency. We find that fulfillment of desires often feed into new desires or consolidate old desires. At best, fulfillment of grosser desires can change them into subtler desires. Such a comprehension is an important advance towards answering the fundamental questions of human existence and purpose. One now begins to look into horizons beyond desires. Then one is ushering into the common realm of science and spirituality. Is the inner chore of our psyche seeking fulfillment of desires or seeking freedom from desires. Where lies real joy? In the fulfilment of desires or in the freedom from desires? This question lies at the meeting ground of science and spirituality.

The desire to know and to understand is the prime mover of science. The phenomenal world is fascinating. Jt calls out for understanding. Let us pause for a moment and look at the process of understanding itself. When do we think that we have understood a phenomenon ? When we can answer the following two questions about the phenomenon. What happened? How did it happen? First question requires a description. Second question requires a notion of causality. Scientific description of a phenomenon can be quite different from a layman's description. There is an insistence on precision and measurability from a scientific description. Jt is also analytic. First one has to discover the constituents, which are the simplest entities in terms of which the whole phenomenon can be thought to be composed. There should be no need to fragment the constituents themselves, i.e, the constituents should have no inner structure. Second requirement is ordering and sequencing. One cannot describe all at once, it has to be done part by part, one after another, this is ordering and sequencing. The substratum of ordering and sequencing is space and time. They are the most essential and universally available means. In fact one should examine if this is the only role of space-time. It is important to realize that simply the desire to describe a phenomenon has demanded such fundamental pre-requisites as the elementary constituents, space, and time. The list of demands is not yet over. One has to endow the constituents with dynamical properties like mass, charge, magnetic moment etc. Their space-time dependence, atleast when left alone, should be prescribed. When a constituent has a single spatial specification it is called an elementary particle. When a constituent is spatially spread out, it is a field. Transport in space and time of the constituents and the dynamical properties is the description of the phenomenon. That constitutes the answer to what happened. Now we come to the second question. How did it happen? This requires a sharpening of sequencing into causal sequencing. The observer is no longer in command in deciding the sequence. There is now a demand for the discovery of nature's laws. Tt spells out how nature provides for unique sequencing and ordering of the constituents and properties. That there must exist laws of nature is the basic faith in science.

The touch-stone of the discovery of correct la ws of nature is prediction - sharply defined and otherwise vulnerable prediction. Prediction is also the touch-stone of understanding. What we have discussed so far is only half the story about understanding. Understanding involves both the phenomenon and the observer.

We have talked about the phenomenon. Now we study the implication on the observer of understanding. Observer's mind is clearly the means of understanding. When do we say that we have understood ? Compare this question with the earlier posed question: When do we think that we have understood a phenomenon? Now we are posing a question pointing towards the observer, earlier we were posing a question pointing towards the phenomenon. If we enquire into the workings of a scientists' mind one finds that he carries a logical frame-work in his mind as a frame of reference for the study of any phenomenon. The logical frame-work must have universal acceptance by all the scientists. The elements of the logical structure are put into correspondence with the elements of the phenomenon viz , constituents, observable properties, and space-time. Rules are formulted within this structure to correspond to the dynamical la ws. The scientist feels that he has understood the phenomenon if he can find such a logical structure which looks like the image of the phenomenon within his mind with not only complete correspondence with all elements of the phenomena at an instant but at all instants. This means a perfect imaging of also the dynamical la ws giving time evolution. Thus understanding is a correspondence between what we observe and what our intellect has conceived as the right logical structure for it. The right logical structure, with its organization, precision, economy, and far spread out implications is the ultimate that intellect can conceive. This is the incarnation of beauty in the intellectual world. Thus, understanding is a correspondence between what we observe and what our intellect conceives as beautiful.

Notice carefully that understanding lacks newness. There is nothing fresh about it. It is bound by. the already known. It is correspondence with a stale frame-work. But each phenomena is new and fresh moment to moment. It's always new as it did not happen before. We then begin to suspect if intellectual understanding is highly mutilated. We realize that for comprehension of the ever new, freedom from the known is important. Here then we are in a twilight zone between science and spirituality. The movement from the known to unknown, from understanding to truth is the movement from science to spirituality.

Let us look at the largest drama on the surface of the earth enacted by the entire humanity. In this drama let us perceive the patterns with largest expanse in terms of space-time and in terms of the number of individuals involved. What do we see? There are fantastic movements of socio-economic construction. Growth of religious and political alignments. Growing communication bet ween communities and individuals. Effective shrinking of the world. Side-by-side there is the growing virulence of wars, growing crimes and conflicts within communities and between communities. The security that a community provides to an individual member is also the cause for insecurity due to friction from the neighbouring communities. The comfort of affluence is also churning up jealousies amongst the not so affluent, leading to tragedies. Every movement seems to carry germs of its own negation. Thus there is love and hatred, pleasure and pain, peace and war as if two faces of the same coin. We are always faced with problems and we are eternally seeking solutions. But each solution is sowing the nee t problem. We are on the move, but in all directions; Can we get out of this dynamics totally? Should we? What is the source of energy for this chaotic movement? Can we be the master at the very source?

When the comprehensive appreciation of the dynamics of the outer- world has inspired an individual to realize that the source of conflicts lies within the psyche of the man, when he has seen through the futulity of finding security in the outer configurations of communities, politics and religion then he is on the path to spiritualism. The vagaries of the objective world has pointed towards the subject. That is the beginning of spirituality. When division between man and man, alignments arising out of convictions, faiths, and thoughts become obselete we are perceivmg first glow of spiritualism. A deep look at the self, without objectifying it, is the first step in spirituality. This is also the last step. There are no further steps. Because now we enter the land of the pathless.

An outer symptom of spirituality is total absence of conflicts. Unlike religion and like science, spirituality does not lend itself to creating schism between man an man.

Intellect is the seat of science, self is the seat of spirituality. But an individual is indivisibly complete. There is no compartmentalization like I self and intellect. There is no demarcation between spirituality and science.

The world of phenomena is before us. The intellect is lured to understand it. We observe that understanding saps the phenomenon its freshness and puts a distance between the observed and the observer. It brings between the two a theory, a frame of reference. This masks direct perception. It may sound contradictory but understanding is negation of truth. Understanding is illusion because it is seeing through a mental construct which does not exist on the level of the phenomenon. Can we see this? Can we see how intellect has to create a whole world within itself, the image world, in order to discribe and understand the outer world? Can we see its failures? Can we see how the image world excludes the subject, excludes self a wareness, and truth? The perception cutting through all mental constructs, all theories, all logic, all value system alone can lead to truth. The intellect that conceived space-time, that conceived logical structures, that conceived social and ethical value system, that inspires us shedding of all pettiness, ultimately reveals its own limitations and brings us to the threshold of spirituality. With a deep sense of gratitude we bid good-bye to the intellect. It brought us to the platform from where on jumps into the pathless sky. Now theories fade out, value system withers away, good and bad recede, pleasure and pain become non-entity, There is direct perception with no intermediary. There is a warenss.

The problems of humans and human society are infinitely many. That keeps us in business. When we say that a preblem is solved we mean that it has been effectively replaced by another. Progress consists of transformation of grosser problem into subtler problem. Problem of starvation converted into problem of balanced nutrition. Problem of war converted into problem of unparliamentary debate. The means of solution also get subtler - from crude acts of violence to appeal to better sense. The supreme deity presiding over this human drama is the human intellect. That is the subtlest equipment with us capable of rising above all pettiness. A society is civilized if it appeals to intellect to "solve" its problems / and a society is uncivilized if it masks the intellect and attempts to do justice on the basis of prejudices. Scientific effort spring from intellect exclusively and hence is incapable of pettiness and prejudices. That is why science, along with the intellect preside over the process of civilizing the humans.

This process has not gone far. We are still beset with problems at very crude level. However, the terror of war and possibility of total annihilation has immensely contributed to a sense of urgency to rise above all wars. Today delicate balance of armament and strategy is keeping the war at a distance. This is an unstable equilibrium under high tension. Before the all annihilating explosion occurs we have to quickly move towards a stable equilibrium without any tension. Tension cannot be removed by an opposing tension. We have had revolutions based on thoughts and ideals - which has al ways meant force or coercion by one section of the society on other. Some of these revolutions could even be classified as progress. But they are all super fecial revolutions replacing one kind of stress by another. It is easily realized that evil is a stress but if we see carefully we find that a lofty ideal is also a stress, coercive and alienating. Greatest of all revolutions will come by deep understanding based on extensive unbiased information. In this process there is no ideals to be sold or insisted upon. Hence there is no use for force or coercion. There is no alienation. There is no victor, no looser. It only loosens the grIp of evil tendencies and of lofty thoughts which are al ways self righteous. There will be a most thorough revolution at the very foundations of human society. We would then be ready to say good-bye to politics, religion and socio-economic straight jackets and usher into an era of spirituality.

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Science, Technology and Spirituality: Impact on Quality of Human Life

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INTRODUCTION

Man's curiosity for understanding nature in all its aspects has led to systematic probing into nature and her mysteries, where each piece of knowledge has been a revelation, inspiring him on to the track of many more. It is also well-known that since the days of unrecorded history of human existence, man has been engaged in technological development to fulfil his needs for food, shelter, safety, comfort and many other aspects of social and culture life. Research in physical and applied sciences has not only been continuous but one of ever gathering momentum as well.

In the mechanistic world of today, technology occupies the pride of place. There seems to be a mad race for maximum utilization of natural resources by the use of technological innovations. Material abundance is regarded as the yard-stick of progress and culture. Naturally, therefore, the third world countries marvel at the prosperity of the advanced western world and are aiming at attaining a similar status for their people. However, there is another side of the picture which needs serious consideration. While, on the one hand, we witness a progress towards the nuclear and space age, use of rockets and space vehicles for exploration of space, unlimited applications of computer and electronics, advances in biological and other branches of science, etc, on the other, there are mounting problems arising out of accidents of nuclear power plants, danger of nuclear war, spiralling inflation, violence over fuel allocation, loss of productivity and jobs, pollution and decay of the eco-system and health hazards. Why is there unhappiness and mounting social problems in the more affluent and technologically advanced countries? Are the natural resources limitless so that the process of their exploitation can continue at an exponential rate? Does the quality of human life depend only on material abundance? To answer these questions a closer look and a deeper understanding of the implications of the modern trend and their consequences, keeping in view the effect on the future generation in particular, is necessary It is apparent that a change from the mechanistic world-view would be necessary. We shall try to discuss some of the major problems and focus our attention to the way we should orient our life-style and define the quality of human life consistent with peace and happiness for mankind, present and future. Scientists have always been in search of answer to the 'hows' and 'why's' of things that occur in nature using sensual evidence techniques. They are deeply interested in the philosophical implications of modern physics and are aiming, continously and without any prejudice, to improve upon their understanding of the nature of reality. Spiritual thinkers of the past also had similar objectives, but their method and approach was mainly through development of inner consciousness. Although there is great similarity in the findings of scientists and spiritualists, yet there seems to exist a conflict between them. There is a revolt in certain auarters aaainst Eastern mysticism which arises from logical positivism and existentialism. Many scientists are brought up in a tradition that associates mysticism with things vague, mysterious and highly unscientific. According to them, nothing can be true or even meaningful unless it can be understood in terms of sense experience. Some are even shocked that their ideas are compared with those of mystics. This attitude is, however, not universel amongst scientists. As a matter of fact, a definite change is noticeable among many scientists of repute to whom Eastern thoughts are no longer viewed with ridicule or suspicion but are taken seriously. They are increasingly finding a meeting point between science and spiritualism at the highest level. This union of two thoughts is bound to have tremendous effect on the future world view, which will guide mankind to adopt a way of life based on more realistic value judgement. Men must evolve a way of life in which basic social, ethical and spiritual values are in happy adjustment with material achievements.

IMPACT OF TECHNOLOGY

Human progress, as understood in the modern world, is associated with the phenomenal development in science and technology. Large scale exploration of nature and utilization of vast natural resources using technological tools, have direct bearing on man and his life. As mentioned earlier, rockets and space vehicles are used for the exploration of space as also for collection of purposeful data by rneteoroloqlsts and other scientists. Extensive utilization of computers are being made not only for scientific investigation, information storage and retrieval, control and guidance, data transmission and processing and many more scientific applications, but also for almost all areas of our life, including industrial management, business Iadministration, banking, traffic control, language transmission, cataloging and recording in libraries, education and many other fields. Vastly improved communication system, unlimited number of automatic gadgets and utility goods for household purposes, mechanized agriculture, instrumentation for medical science and many other gifts of technology have indeed contributed immensely towards human comfort and revolutionized the standard of living of the people. Thus, not only the basic human needs of food, clothing and shelter but also all other areas of social and cultural life including public and national safety, health and entertainment bears the mark of technological development. Evidently, all these have been made possible by explosive industrial development utilizing immense amount of energy obtained by conversion of natural sources to usable form. As the progress continues the requirement for energy continues to grow. It is very necessary to visualize the effect of the changes that may emerge in this technological era. In particular, one should bear in mind the availability of adequate sources of energy that would be required to support the technological growth rate. Energy is a primary need for sustenance of life. With the progress of civilization man's needs of energy have been continually growing. With the explosive growth of population the utilization of energy is also growing at an alarming rate.

The seriousness of the energy problem is perhaps best understood when explained on the basis of the law of entropy of classical thermodynamics. It may be recalled that the first and second laws of thermodynamics are the fundamental laws used by physicists and engineers in the study of heat and thermodynamics. The first law is the law of conservation of energy, wherein it states that all matter and energy in the universe is constant. It can neither be created nor destroyed but the form or state may be changed from one to another. The second law is the entropy law, which states that energy can be changed only in one direction, ie, from available to unavailable or usable to unusable or from ordered to disordered. It is a powerful scientific tool for unfolding all physical realities. As such, Einstein described this as the 'premier law of all sciences.' Eddington calls it the 'supreme metaphysical law of the universe.' Every time there is a transformation of energy from one form to another, there is a penalty to be exacted and this penalty is the loss of available energy to do further work, ie, transformation to unavoidable form. Increase of entropy means decrease of available energy and the unavoidable energy is pollution. The entropy law holds good in almost all areas of human activity including technoloqy, economics, agriculture, education, health, etc. Entropy law is valid in the physical world of space, time and matter where everything is finite. It is, however, not valid in the world of spiritual transcendence but none the less it is governed by the same.

It is easy to realize that in this technology era, the entropy is ever increasing. The utilization of energy today is thousand times greater than in pre-historic days. Since there is no creation of energy, it is continuously being transformed from available to unavailable form. If we trace the process of human progress from its primitive stage to the present stage of technological wonders, we shall find that the rate of progress initially was extremely slow. Gradually it gathered momentum as it moved through primitive to agriculture and then from agriculture to industry. Whereas the first change' took millions of years, the second phase took only a few hundred years. The rate continues to become faster and faster so that there is alarm at present due to depletion of non-renewable sources of energy. The two major causes of the energy crisis are faster industrialization and explosive population growth.

The amount of energy utilized is often regarded as the criterion for judging the prosperity of a country, since it means greater amassing of material wealth. On this basis western countries like the USA and Japan are considered to be most prosperous, of which the USA alone utilizes one-third of the total available energy of the world with only 6% of world population. The maldistribution of the world's energy is thus very evident.

Basically there are two sources of energy available to us, viz, terrestrial stock and the solar flow from the sun. For practical human purposes, the terrestrial stock such as fossil fuels, nuclear source, etc are all non-renewable in nature. Fossil fuels such as coal, oil and natural gas are fast getting depleted. Although all the sources available in nature have not been explored, yet the danger remains as the rate of utilization far exceeds the discoveries of untapped sources. Since the natural sources are not infinite there is all possibility of attaining an energy watershed in the near future so far as fossil fuels are concerned.

In view of the possible danger of depletion of fossil fuels, nuclear fuel is being considered as a reliable altemative source by many. However, extensive use of nuclear energy at the present state of experience can be considered as controversial. This is due to the possible health hazards caused by inadequate safety measures for radiation protection and problem of disposal of nuclear waste. According to one report of the Federal Radiation Council (FRC), USA. ‘Every use of radiation involves possibility of some biological risks either to the individual or his descendants.

The management of high level radioactive wastes produced in larger quantities in reactor fuel elements presents a serious hazard associated with nuclear power generation.

In liquid form, high level wastes contain several hundred to several thousand curies of radioactivity per gallon and some of the radioactive elements will remain hazardous for centuries.

Strontium 90 when dispersed into the environment enters the food supply and tend to concentrate in human bones. Ceseum 137 wastes remain hazardous for 600 years. Thermal discharge drastically affects aquatic life, water quality, density, viscosity and gas solubility.' Most of the above conventional energies used today result in excessive centralization. They are antiecological, high entropy, inflationary and unhealthy.

Solar energy, on the other hand, is available from an unlimited source and is pollution free. As such there is no doubt about its superiority as a pollution-free unlimited source and the world is likely to move towards a solar age. However, the main limitation is that it is based on diffused flow and as such its use, at the present state-of-the art, is restricted to small applications and for large industrial purposes. The use of solar energy collectors, wind generators, organic farming, regional and local food production and processing, recycling of waste products, etc come under the category of a new technology called 'Soft Technology' which has reduced impact on the environment. In addition, it uses small scale decentralized systems which are labour intensive, non-inflationary, and it sustains the eco-system.

SCIENCE AND SPIRITUALITY

It is well known that science and metaphysics, both aim at finding the truth about all phenomena that occur in nature. And yet a conflict exists, wherein some scientists do not seem to have any faith in spiritual methods. On the contrary, they do not hesitate to even ridicule the spiritualists and consider them illogical and unscientific. We shall try to analyze some of the sophisticated scientific methods and compare their discoveries with the realization obtained through meditation by the spiritualists. The revolt against traditional metaphysics has developed mostly during the 20th century. From the early period of Rig-veda down to modern times, philosophy in India has been speculative. The revolt against metaphysics appears to be due to logical positivism and existentialism. Man can have no knowledge of anything but phenomena. The knowledge of phenomena is relative and not absolute. Objective universal values are desired. Man must create values for himself through action and by his own living.

The conception that it is only by sense experience that anything can be accepted as true or meaningful existed among some even in earlier days. We find contradiction to this in ancient Greek as also in later European thoughts. For example, Protagoras accepted it but Plato criticized it. Hume denied the existence of God, soul, immortality or even objective moral standards which Kant contradicted and refused to agree to.

Again, if sense experience is the prime criterion for such acceptance, then a question may legitimately be raised whether all scientific principles are capable of such verification. The answer is in the negative. There do exist many universally accepted scientific principles which cannot be verified by sense experience. For instance, we do not observe electrical energy, gravitation or relativity, although their effect can be verified with the help of specially created circumstances and with mathematical calculations, ie, an indirect verification. Such indirect verificational methods are also used for metaphysical theories. According to Dr S Radhakrishnan, 'There is always a tension between logical analysis and existential experience. Any adequate philosophy should be sustained by the integrity of reason and the claims of inward experience.' The scientists in the 20th century have been focussing all their attention to the micro-world in search of more and more elemental particles of matter with a view to understanding nature in all its aspects. As more and more elemental particles are discovered, more and more appear to remain unexplored. This unending process is causing disillusionment and frustration. In fact, 'objective observation of atomic particles is an impossibility,' says Heisenberg. A sensational realization of quantum physics that simultaneous determination of both location and veiocity of an object is an impossibility, and known as 'Heisenberg's Uncertainty Principle,'overshadows the very basis of classical physics.

Modem physics is the basis of natural sciences and it influences all aspects of human society. The combination of natural sciences and technological sciences have brought in a fundamental change in the life-style of mankind in ways which are both beneficial as well as detrimental. Whereas on the hand it has contributed to the development of industry, agriculture, transport, communication, health and many other aspects beneficial to society, on the other hand the present day horrors of nuclear war is also a gift of atomic physics. Natural sciences have a definite influence on human culture as also on man's conception of the universe and his relation to it.

The original classical ideas of Newton and Rene Descartes had certain limitations which were revealed by the exploration of the atomic and sub-atomic world. The necessary revision came in on the concept of matter. Studies in sub-atomic physics has changed the concept of matter as also time, space, cause and effect, which differ from those of classical ideas. How interesting it is to note that these changed ideas led to a world-view which is very similar to those obtained from Eastern mysticism. Although this parallelism has not been discussed extensively, yet it has highly impressed many top scientists of the world. Thus, Julius Robert Oppenheimer says, 'The great notion about human understanding which are illustrated by discoveries in atomic physics are not in the nature of things wholly unfamiliar, wholly unheard of or new. Even in our culture they have a history and in Buddhist and Hindu thoughts a more considerable and central place. What we shall find is an exemplification and encouragement, and a refinement of old wisdom.

Similar remarks have also been made by leading world scientists like Neils Bohr and Werner Heisenberg. Historically, western science started originally from mystical philosophy of the early Greeks. Gradually with the development of the thought process, a drift occurred and the scientists started turning away from the mystical origin. In the final stage and as it stands today the trend is again reversing and it is coming back towards the early mystical origin. This change is not merely based on intuition but on sound experimental verification of great precision and sophistication and supported by rigorous mathematical formulations.

The most important revelation of the Eastem view is the awareness of unity and material inter-relationship of all things and events. Manifestation of basic oneness prevails all phenomena. All things are considered to be inter-dependent and inseparable part of the cosmic whole. They are but different manifestations of the same ultimate unity, called Brahman by the Hindus and Oharmakaya by Buddhists.

Again in the field of modern physics the Coppenhagen interpretation of quantum theory, developed 'by Bohr, Heisenberg and Strapp sets the starting point. Physical world is divided into the observed system (object) and the observing system. The observed system may be an atom, a sub-atomic particle, etc and the observing system may consist of sophisticated experimental setup inclusive of the human observer. Starting from this, there have been various attempts using statistical and other methods to arrive at a definite conclusion. But difficulty arose in defining the location of a sub-atomic particle at a certain time and also to ascertain how the atomic process occurs. Finally, the quantum theory accepted among others, the inter-connectedness of the Universe. Although the Coppenhagen interpretation of quantum theory is not universally accepted, the interconnectedness of things and events has been accepted as fundamental. David Bohrn, one of the main opponents of the theory, also accepted the above which is revealed from the following statement: 'One is led to a new notioh of unbroken wholeness which defines the classical idea of analyzability of world into separately and independently existing parts. We have reversed the usual classical notion that the independent 'elementary parts' of the world are the fundamental reality, and that the various systems are merely particular contingent forms and arrangements of those parts. Rather we say that inseparable quantum inter-connectedness of which the universe is the fundamental reality and that relatively independently behaving parts, are merely particular and contingent forms within the whole.'

The experience of all things and events are manifestation of basic oneness according to Eastern thoughts and yet all things are not considered to be equal. Individuality of things is accepted but differences and contrasts are considered as relative within an all-embracing unity. Opposites are abstract thoughts which are relative in the realm of intellectual concept. Thus, good and bad, pleasure and pain, life and death are but two sides of the same reality and not absolute experiences of different categories. Opposites also exist in sub-atomic studies where particles are both destructible and indestructible; matter is both continuous and discontinuous, while force and matter are different aspects of the same phenomenon. It is possible to draw further parallelism oetween Eastem spiritual thoughts and the theories and laws of modem physics. One important such parallel is the four dimensional space-time relativistic consideration applied in the study of particle interactions in sub-atomic physics and the intuitive notion of space-time in Eastem mysticism obtained particularly in Avatam Sake school of Mahayana Buddhism. The rhythm of creation and destruction, the emission and absorption of virtual particles have also been described by some as subatomic dance analogous to Shiva's dance.

Concept in modern physics have undergone several changes in the past. Thus, the explanation of the physical world in terms of structures of nucleus and elementary particles like atoms, nuclei, hadrons, etc was found to be inadequate. Sub-atomic physics abandoned the mechanistic view of simple building blocks and suggested particles as processes rather than objects. It revealed the basic inter-connections of matter and showed that the energy of motion can be transformed into mass. The concept of elementary particles or fundamental fields was rejected in particle physics. The Bootstrap hypothesis explicitly rules out that the universe was constructed from a set of basic entities which cannot be analyzed further, rather it may be seen as a dynamic web of inter-related events. None of the parts of this web have properties which are fundamental. They follow from the properties of other parts. The structure of the entire web is determined by the overall consistency of their mutual inter-relationship. This view is in harmony with Eastern thoughts. The two comprises different aspects of the same idea.

Laws and theories of modern physics relating to nature have been realized as creation of human mind. It is not the absolute reality but only a mental conception of reality. Scientific theories and laws are all approximate and not absolute. Although the error due to the approximation is reducing with further studies and investigations, it is improbable that it will ever become absolute.

The error involved, however, is small enough and hence does not affect a reasonable understanding of nature. For instance, the effect of gravitational interaction in particle physics is usually ignored since it is smaller than other interactive forces by many orders of magnitude. Such approximate or relative knowledge is unacceptable to the Eastern mystics and philosophers. They are interested only in absolute knowledge in the understanding of totality of life. Since this is not possible, they insist that no single phenomenon can be explained.

Again the question of consciousness arises in quantum theory in the observation of atomic phenomenon. There it is assumed that these phenomena can be understood only in terms of consciousness of the human observer. In this connection, Eugene Wagner says, 'It was not possible to formulate the laws of quantum theory' without reference to consciousness.'

Understanding of one's consciousness and of its relationship with the rest of the world has been explored by the Eastern mystics over the centuries. This may perhaps be the starting point and an exciting possibility where the physicists and the spiritualists may directly interact with each other, one complementing the other.

I am tempted to cite another example where the saints of the past could extend their vision by spiritual practice to a range which the scientists at a later period could achieve only through a highly sophisticated instrument system. This is in the field of astronomy. Astronomical observations using highly sophisticated instruments discovered the solar system and the great ensemble of galaxies since the beginning of the 20th century. Is it not surprising that with no such instruments available, Hindu saints could acquire very similar knowledge thousands of years ago? Manu Smriti (Laws of Manu) clearly stated that the earth is not at the centre of the universe, but like its surrounding planets Venus, Mars, Jupiter, Saturn, etc it is one more satellite of the sun, around which it gravitates in their company. The gods of Trimurti-Brahma, Vishnu and Siva-were considered as operative deities from the cosmic point of view. Production of our solar system in all its detail is given in the above laws. It is clearly stated that the sun is only one star among the myriads of other stars. Trimurti's role in the formation of the solar system, the infinite celestial spaces, in which the myriads are grouped in immense clusters of millions of stars revolving around their centres, has been clearly described. It is indeed amazing how these laws coincide with the latest discoveries in astronomical sciences.

IMPACT ON QUALITY OF HUMAN LIFE

We have discussed the role of entropic law in the context of energy crisis and stated that it is applicable to all areas of human activity. It is a powerful tool and it provides a scientific frame-work for unfolding the realities of all physical activities in the world of finite things which are destined to ultimate decay. It is likely that a new world view based on entropic law would replace the Newtonian worldview as the organizing frame of history.

In a high entropic culture, the purpose of life becomes one of high energy flow to create material abundance and satisfy every conceivable human desire. A primary value is placed upon transforming the environment to extract its riches and ultimate purpose of our existence is confined to satisfaction of all possible material wants. In his book 'Entropy,' Jeremy Refkin says, 'Reality is reduced to what can be measured, quantified and tested. We have denied the qualitative, the spiritual, the mataphysical. In the process, we have destroyed family, community and tradition, discarded all absolutes except absolute faith in our ability to overcome all limits to our physical activity.'

Entropic law answers the central question in culture, ie, how should human beings behave in the world. Can we not agree that people should act in a way that preserves and enhances life for which energy is an absolute necessity? Since there is a continuous depletion of energy sources it is our moral imperative to waste as little energy as possible. This is the only way we can express our love of life and our loving commitment to the continual unfolding of all life.

What a wonderful thing it is to become overwhelmed with the concepts and discoveries like entropy and radioactivity, statistical distribution law related to velocity in the molecule and the laws of sub-atomic particle interaction. Electromagnetism and the electro-magnetic theory of light, mfra-reo and ultra-violet radiation and the wave character of light-all are the outcome of systems of logic that are the product of the human intellect.

We accept science because it satisfies human reason. The consistency of logic is the mainstay of any principle to be accepted as science. Human search for absolute values never remains confined by the parameters of things, visible and measurable. Human intellect in its dynamism transcends all constraints of physical narrowness and enters the realm of the invisible, the immeasurable. But logic continues. The power of reason is never abandoned.

When the search for absolute values changes its direction from the objective world of experience towards the subjective realm of perception and intuition, a great Change takes place. The change is in the transformation of the physical into the metaphysical.

We have reached a period of time when it is perhaps hardly possible to isolate one from the other-to differentiate between physics and metaphysics. Because both are specific systems, consistent in having reason as the tool to conduct the search to identify the absolute.

Can we separate the perception of objectivity from the awareness of subjectivity? Science as a whole has its charm in its mystery of subjectivity-objectivity complex.

Human intelligence is a product of matter and is relative in character. What is in itself within the area of relativity cannot measure the beyond which is absolute. So intelligence cannot demonstrate what is absolute but in a discursive way can indicate it.

We live in a great age when we find that the concept of spirituality and the principles of exact sciences are moving from divergence to convergence. The integration is the finding of exact sciences or energy as the factor underlying all beings, things, events and consciousness. Science is still silent about the beyond of the findings, whereas spirituality declares the beyond to be the intuitive realization of dichotomy transcendence.

Man in his psycho-physical existence projects himself in its thought, action and behaviour definitely as a being conditioned by psychosomatic factors. It cannot be denied that mind can recondition his thinking process by deliberate cultivation, culture and exercise of his psychosomatic system. The recognition of the systemic view of human character can create the conditioning based on objective reasoning that human quality improvement-can be induced through such exercise as culturalization.

Our time is great. My contention is that the people all over the world are restless to change the socioeconomic and environmental condition of their life. Human mind is posing a challenge to their own positions, created by the economic theory enunciated during the last few centuries and the pattern of development and progress propagated by a type of political thought which itself is blind about humanness but extremely sensate in its drives. This has created a crisis. The deepest of the crisis is the moment when the real man comes out epressing his identity through pure mind, large heart and actions motivated by the blended force of clear intellect, contained emotion for the meaning of life and for the purpose for which man lives. Please stop and listen, listen in silence. Do you hear the human cry for the meaning of life? Do you hear that man has found himself deficient regarding what is humane and feeling himself as the poorest? Man wants to become a whole and complete. Poverty is deficiency. It is measured by the degree of hunger and want. Man has discovered that increasing the demand for higher standard of life is a force that makes him poorer and poorer. But when man is complete and there is no want, he finds in himself the wholeness and overcomes poverty of any kind. This state of human character reflects the quality of human life.

Now we are to decide whether our drives should be the strongest for the increase in standard of life or for human quality improvement. It is the question for decision making. Our life gives us the fullest of exposure to make our choice. Let us choose on the basis of our own reasoning.

The Emerging Educational Scene: Increasing Emphasis on Relevance

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Among the many changes that the 20th century has witnessed the most significant perhaps is the emergence of education as a major resource in a nation. Though the term education is as old as civilisation, its role, content and importance in society, have undergone major changes. In the agricultural civilisation, education was an ornament, an embellishment and a leisure time pursuit. It became a tool for economic development in the industrial civilisation. In the high technology era of to-day, it has become a resource, perhaps the most precious of all resources.

The western nations realized the economic value of education much earlier and gave themselves the benefit of education with due emphasis on its social, cultural and economic importance. Even with them, the dimension that education has attained after the Second World War signifies a major revolution in the class rooms and the laboratories.

As for the countries in the Third World, they woke up to the situation only in the second half of this century. Many of them attained freedom and became masters of their destiny only during this period. We happen to live and work, no doubt, at a remarkable period in the history of human progress. Whether it be political organisation, economic philosophy, human values, material development, social. changes or technological development, we have been witnessing changes and developments which might perhaps exceed those that have taken place in the millennium preceding this century. In this process, education has played a significant role and has also emerged as a dominant and decisive force, more than ever before.

If we survey the world scene, we see that it stands divided into two major camps, cutting across religious faith, political conviction, linguistic affinities and other binding forces. They are:

* the advanced nations and
* the developing nations

now being referred to as the North and the South.

As per the UNDP report of 1983, the former accounts for a population of 1.1 billion ie, 23% of the world population. They occupy 40% of the area and command 80% of the resources. The latter accounts for a population of 3.6 billion and have the rest of the area and the resources.

What really has contributed to the privileged posttion that the North enjoys is a matter for consideration. Prof Abdus Salam, the Nobel prize winning physicist says.:

"Today, the Third World is only slowly waking up to the realisation that in the final analysis, creation, mastery and utilisation of modern science and technology is basically what distinguishes the South from the North. On Science and Technology depends the standards of living of a nation. The widening gap in economics and influence between the nations of the South and the North is essentially the science and technology gap. Nothing else-neither differing systems of economics nor of governance, nor differing cultural mores, nor differing perceptions of religious thought,-can explain why the North (to the exclusion of the South) can master this globe of ours and beyond".

Stated in simple language, it is their education — its spread, its content, its relevance and its effectiveness — that has really made the difference. As this century approaches its close a few things have become clear:

* Education, besides being a refining, civilising and cultural force, is now inseparably linked to economic development.

* Traditionally we were concerned with the education of those whose intellectual capacity was high. To-day, society needs varied talents; the researcher, the designer, the practitioner, the manager, the executive, the supervisor, the political leader, the businessman and many others. The educational programmes have to cater to

the instruction and training of all these classes of persons in order that, not their intellectual capacity, but their ability, which includes intellectual capacity, is developed to the maximum extent.

* It is also realised that since able people are distributed among all strata of the society, the chances of picking up the able ones increase with the increase in the coverage of the population.

* Equality of opportunities is not only a socially desirable concept, but it is also a necessary requirement for economic development

These bring into focus three aspects of education, namely:

• equity or equality of opportunity
• excellence and
• relevance.

All of us are familiar with these aspects. Excellence is an attribute that is needed not only in education, but in every area of activity. It is a pervasive quality and has to be inherent in an act: it has no separate existence. It is the culmination of endless improvement in anything we do, and we should strive to achieve it in every endeavour. Roughly stated, the usefulness of any service to society is a function of the product of its quantity and quality. We try to maximise not both, but their product, realising that if anyone of the two tends to zero, the product tends to zero. In any effort quality and quantity have to be regulated with this fact in mind.

Whatever be the activity or the product and its quantity and quality, the relevance is of paramount 'importance. However large the quantity and however high the quality, an irrelevant action or object is of no consequence. Progressively, relevance in education has emerged as a dominant characteristic and an attribute demanded by society. We perceive its importance: accept and acknowledge its need, but frankly we do not know how to achieve it.

We realise that:

* for quantity, there is a measure and
* for quality, there are standards,

but how do we specify and achieve relevance? A simple answer does not exit. We have been groping towards a system: we are exploring for a strategy.

Our education has many critics: they are drawn without exception from all classes and categories of people. It is principally found fault with for lack of relevance; ie, for its failure to relate its instruction and training to the existing and emerging needs of our economy. We may consider this aspect broadly for:

* school education
* general education in arts and sciences at the university level, and
* engineering education.

In the school, we may take it that the period of the child from the 1st to 10th standard is meant for general education. The question often arises whether it should be from the 1st to the 8th standard or up to the 10th. For a developing country like India, undifferentiated general education up to the 10th standard is an ambitious target. Many European countries even to-day start preparing the children for an occupation at the end of the 8th standard. However, the Kothari Commission has recommended an undifferentiated education up to the 10th standard and we may not think of any change in this regard.

The modern world sees rapid changes and improvements in every area of activity. The situation demands from everyone, a capacity for self-learning, adaptability and resilience of mind and these are normally improved by a sound basic preparation. On a long term basis, diversification at the age of 16 or at the end of 10th standard appears desirable and our present practice is in order, viewing it on a long term basis. The question now is what do we do in the last two years of the school system, that is, at the 11 th and 12th standard, to impart into the instruction and training some relevance to the needs of the economy.

As early as 1854, ie, 135 years ago, Col Wood stated in his despatch that the instruction in Secondary School should be 'practically useful to the people of India in their different spheres of life' and desired that the new schools which it proposed to establish should 'provide more opportunities than now exist for the acquisition of such an improved education as will make those who possess it more useful members of society in every condition of life'. The Despatch contemplated the provision of vocational or prevocational instruction at the secondary stage.

Since Wood's Despatch, successive commissions and committees recommended the introduction of vocational education at the secondary stage. The Indian Education Commission (1882-83), under the Chairmanship of Hunter, recommended specifically the bifurcation of the secondary course at the upper classes of the High

School: one leading to the entrance examination (matriculation) of the Universities and the other of a more practical character intended to fit the youth for commercial or non-literary pursuits. Since then many committees and commissions touched on 'this topic though no significant change has been made till to-day.

The Education Commission, headed by Prof Kothari, recommended the introduction of the vocational stream at the +2 level: the progress made at the end of the Sixth Plan, except for Tamil Nadu, was insignificant. It was contemplated in the Seventh Plan that 10% of the +2 students will be diverted to the vocational stream during this Plan and this will be stepped up to 25% in Eighth Plan. Tamil Nadu has, as per the Fifth All India Educational Survey 1986, about 73500 students in the vocational stream in classes XI and XII out of a total strength of 363970, constituting about 20%: but in the country as a whole there are only 126570 candidates in the vocational stream out of a total strength of 34 40 870 in +2, which works out to a mere 4.0 percent.

The progress obviously is poor. What are the impediments? What are the discouraging factors that we face in bringing about a reform accepted by all states, but implemented with little enthusiasm? The major hurdle is lack of clarity or knowledge about:

* the desirable level of vocational preparation
* the employment opportunities and
* the eligibility of these students for admission to university courses.

Frankly stated, an uncertainty bordering on confusion exists in these issues where some clarity is a prerequisite for the success of this programme. I am aware that NCERT insists upon 70% of the time being devoted to vocational subjects and 30% to languages and theoretical subjects allied to the vocational courses.

In the vocational stream, courses are offered in the following areas:

* Agriculture
* Business and Commerce
* Engineering and Technology
* Health and Para-Medical Services
* Home Sciences
* Humanities
* Others

The vocational stream is independent of, and different from, the well-developed system of technical and vocational education that exists in polytechnics, industrial training institutes, agricultural schools, forest schools, pharmacy schools and others.

Many argue that these courses must:

* be predominantly terminal
* prepare the candidates for salaried employment, and
* be related to employment opportunities available in terms of numbers trained.

These conditions appear desirable: but are not such as to promote the expansion of vocational stream. If these are insisted upon the numbers will remain very small and the reform will not take off.

The programme:

* is located in schools which may not have, even under favourable conditions, the entire equipment that may be needed
* is offered by teachers who may not be comparable to their counterparts in a diploma or certificate school in their education and training

* is part of a curriculum where the students have to learn two languages under Part I and Part II and may also have to take one or two subjects under Part III for eligibility for higher education.

Whenever the educational programme has beef designed to combine general and vocational streams, the idea behind it is that the students emerge from the schooling equipped for some kind of productive work and for academic studies alike. As our thoughts become more and more clear on this reform, we have to accept that the term 'Vocationalized Stream' conveys the concept of the programme more satisfactorily than the term vocational stream. It must be emphasised that the vccatlonaltzec stream is still a part of the higher secondary school education system and is not comparable, either in approach or in the level of skill accomplishment, to the organised vocational education programme outside the a general education system.

As of now we have no worthwhile data on job opportunities even for such well-established areas like engineering, medicine and agriculture. Normally manpower survey and manpower projection are for the organised sector. When jobs for the candidates trained in well-established vocational institutions and schools are scarce, the question of fitting all the +2 vocational school graduates in positions in the organised sector is not realistic. It is futile to aim at one to one correspondence between the vocational stream candidates and salaried jobs.

If the candidates from the vocationalized stream cannot be matched on a one to one basis with available jobs, the question arises as to the relevance of these courses. I may attempt to answer this question. The National Working Groups on 'Vocationalization of Education' has made the following observation.

> 'It is necessary to emphasize that everyone is entitled to education that is useful to him and hence there is the need for introducing a large number of courses at the higher secondary level which in general will be more useful than the academic subjects for those candidates who conclude formal education at the +2 level. A student from an agricultural Iarnlty in a village, who stops formal education and goes to the farm, may find a course in agricultural chemicals, pumps and their maintenance and similar courses more useful than one in geography or history or psychology. It is not necessary that he should be qualified to become a technician in agricultural chemistry or pump maintenance and repair and be able to occupy himself on a full-time basis in that field. It is not necessary to approach vocationalization in the school system with wage employment, or employment in the formal sense of the term alone, dominating our thinking all the time. There are to-day, numerous subjects that are relevant to the economic development of the nation and the day-ta-day life of individuals. They combine skill and knowledge. Training in those subjects need working with things and working with people, and not merely with concepts. At present, subjects of that nature are not found in the traditional higher secondary curriculum. They must now be introduced. The subjects must be so chosen that they are relevant to the economic life in the district or the region. Vocational orientation where necessary, and vocational education and training for employment, where possible, should both be considered as acceptable'.

ln the last 40 years, we have developed a significant scientific ability and technological capability. What is needed is the diffusion of the scientific and technological developments in the country to change, modernize and improve every area of our activity. This effort will need an enormous manpower with a background of modern educational preparation in sciences, social sciences and technology and with a capacity for creative application. The vocationalized stream from the higher secondary education and the corresponding degree courses in +3 stage must supply this manpower which is badly needed for carrying the programme of industrial and economic development to the rural people who constitute 76% of our population. We need all the students coming out of the vocational stream to participate in this gigantic task which will be the next and the most important phase of our development.

When we come to the university stage, it may be surprising, but true that the universities have been and are offering only programmes that suit the requirements of students from the academic stream. It is necessary to substantially diversity the undergraduate programmes and offer courses that will suit the preparation of the vocationalized stream boys and girls who may choose to pursue higller education in the same subject field.

The UGC has 'come forward to assist the colleges that may introduce specially designed job-oriented courses which mayor may not be related to the combination of subjects offered at +2 in the vocational stream. Secondly, even in the case of conventional arts and science programmes, the UGC has suggested that at least one subject may be job-oriented in Part III.

We need to take a critical look at the undergraduate degree programmes. They consist generally of Part I, Part II and Part III; Parts I and II being languages. Only Part III is devoted to the subjects proper in sciences and humanities. It must be examined whether compulsory study of language and literature should be carried to the degree level, and whether the time now allotted for them cannot be reduced. This issue must be approached with objectivity, free from emotional considerations.

While the steps introduced by the UGC in higher education are good, they are not adequate. The colleges should as a matter of policy interact with the neighbourhood. The students must be exposed to the problems of the society and be made to see their education in relation to the societal needs. There are 164 universities, 6570 colleges (1987-88) and if we add to them the 280 engineering colleges (1986-87) and 340 polytechnics (1986-87) and all the Medical colleges we will have nearly one institution per100000 of the population. With 38.6 lakhs of students in colleges, we have one student for nearly every 200 persons. If these institutions can combine their strength with a cluster of secondary and higher secondary schools which are around 19400 and with the students in these institutions, it will be possible to carry the message of science and technology to the rural people. This cannot happen as a mere social service. It must be linked with their education and training. AI least a good project at the end of an undergraduate degree programme which should have a bearing on the life and work of the community around, should form part of the first degree programme.

Relating our education to the social and economic environment is a task that remains to be done. In spite of our efforts all along, it has not been moulded and shaped into an effective tool of social and economic transformation. While school education is looked upon, as a mere theoretical study and a matter of general preparation in letters and numbers, university education is thought of as preparation towards a career for the individual. Consequently a graduate is convinced that society owes him a job and he owes none to the society. Many of our students seem to come out of the portals of higher learning with more frustration and resentment and less knowledge, and no commitment.

Among the professional courses, medicine stands on a separate footing. From its inception it has been integrated with practice and the class rooms and hospitals went together. Deficiencies there may be; but there is no denying the fact that medical education alsways stood close to practice. Whether in advanced or developing countries, there is no professor of medicine who does not examine and prescribe and no professor of surgery who does not operate and heal.

Agricultural education has a long tradition of extension programmes. Teaching, research and extension have remained together and in harmony over a long period of time. The emphasis there will be on identification of research areas relevant to the need of the country and fixing priorities. Both agriculture and medicine are heavily influenced by development in, and contributIons of, technology. The problem is one of absorbing these developments, adopting them to suit the needs and carrying them to the field. Agricultural Engineering has a long tradition; but Bio-medical Engineering is an emerging discipline. These provide an interface among engineering, medicine and agriculture. The educational programmes have to keep pace with all the developments which are partly the contribution of researchers and partly the contribution of field practitioners.

Engineering education to-day faces more challenges than education in any other discipline. The educational institutions remain stratified into five categories.

* Indian Institutes of Technology,
* State Universities of Technology and University Departments of Engineering/ Technology
* Regional Engineering Colleges
* Aided Government and Private Colleges
* Unaided Private Colleges .

These institutions differ in:

* system of management,
* level of funding
* academic autonomy
* administrative auton.omy
* financial autonomy
* content of courses
* quality of instruction
* level of research and
* extension programmes.

Educational institutions of all categories in Engineering, Technology, Management and Architecture come under the purview of the All India Council for Technical Education (AICTE), which regulates, controls and governs almost every activity. Neither the UGC nor the IMC enjoys the near absolute power with which this body has recently been vested by an Act of Parliament. Whether such overriding authority of a central body, which will consist of salaried officers and nominated members, will be in the larger interests of engineering education remains to be seen. The weak link between education and industry is to be seen from the fact that even some of the major professional bodies like the Institution of Engineers have not applied their mind to the implications of the emergence of a body like the AICTE.

In Engineering, the demands from the employers is diverse. The small industries insist on immediate employment which means a narrow preparation: large industries would lay stress on the candidate's possession of a strong basic grounding in sciences, analysis, design and principles of manufacture and they would handle the training aspects. The requirements of the Government departments are hardly spelt out.

Many start claiming that the curricula and syllabi in their university are comparable to those in MIT, or CALTECH, or in one of the well established institutions in advanced countries. While a comparison of such subjects as basic sciences, engineering design and engineering analysis may be in order, we need not and should not unduly bother about matching our syllabi with those of any foreign university. They are educating their boys and girls to meet their needs: and we must educate our boys girls to meet our needs. Unfortunately we have not done it. The situation in this country is that the higher the status of an institution, the closer it is to its counterpart in an advanced country. It is to be conceded that our institutes of higher learning, especially the prestigious ones, first uproot our boys and girls from their culture and then uproot them from their soil. I do realise that a substantial part of the conventional industries and high technology industries are similar to those in advanced countries. They are almost transplants from the West. Even there, many factors are indigenous in character. When it comes to humbler industries, they are substantially indigenous and need persons with appropriate preparation.

Rural industries, agricultural practices, irrigation needs, building materials, housing, rural energy programmes, solar energy, wind energy, biogas and social forestry are some of the areas which will dominate the rural development programmes which touch the lives of 76% of our population. But these hardly find any significant place in our curriculum and syllabi. These courses may not also be considered sufficiently modern, may not be opted for by many students. We see here a deficiency or even a distortion in our engineering education.

We realise fully the importance of Electronics, Computers, and Communication Systems. But development is not merely a matter of computers, microchips and space satellites. Development is a complex process. A few large dams, a sprinking of large steel mills, refineries and heavy industries, though basic and necessary, will not create enough wealth to make the nation rich.

We have very riglltly entered the high technology area and it is necessary even for the developing countries to use these tools. But in India to-day the bullock cart is still as important as tile Boeing. Our technology requirements represent not a small band but a wide spectrum with crafts at one end and high technology on the other.

Conventional and high technology industries are in tile organised sector which employ about 15% of the labour force. Development is a complex process. Heavy industries thouqh basic, medium industries though Iligly necessary, are still peaks scattered over the length and breadth of the country. They by themselves will not raise the base.

Development requires that productivity of every member of the labour force is increased. It needs that a carpenter uses a beter chisel, a better saw and makes two or three pieoes of furniture in place of one. It means that even a humble cobbler uses a better needle, a better knife and makes two pairs of footwear in place of one. It also means that an assistant in the office uses better file keeping and data processing methods to dispose off five files in place of one. The increase in income in each individual case may be small; but the number is so large that the sum total will be substantial. Our research and education must prepare techniques, technologies and manpower that would transform a vast, traditional society into an industrialised one.

In the given state of economy in India, the increase in producnvltv of nearly 85% of the labour force in the unorganised sector is of paramount importance. Developmental programmes must aim at this objective, and education must have its antenna directed to this requirement.

We have often made exhortations for promoting excellence in education: equally important is relevance which means a close correlation between economic development strategies and engineering manpower preparation. Notwithstanding a quarter century of emphasis, on industry-institute relationship, this link remains weak. We see the spectacle that in some of the most prestigious institutions, the best of students are planning from their prefinal year for educational and career opportunities abroad. I make no big fuss about brain drain: but at the same time it does not augur well for a nation if the best of its youth keep dreaming about career opportunities

in a foreign country and looks at the prospects in their own land with scepticism, with lack of enthusiasm and sometime even with derision.

Considering our present stage of industrial development, capacity for research support and adequacy of manpower, India can be said to have reached a stage when it can develop a model of its own for technical education as well as economic development. Our social, cultural and economic systems being unique we cannot transplant any system from a foreign soil and succeed in our objectives.

After four decades of bold and in some ways pioneering experiences in development, the Chinese record- that 'this trend points unmistakably to the fact that the study of development strategy is an urgent need in China's modernisation'. Stating that the general objective is

> 'to first enable the Chinese people to be comparatively well-off by the end of this century, and from this basis to proceed gradually to a higher degree of rnodernisation'.

they ask the following questions after 40 years of experience in economic development:

* What is the road to take?
* What are the steps to adopt?

and provide a general answer that we must:

> 'extricate ourselves from set patterns, old and new, so that we can have a clear and exact understanding of the conditions of China, and the interrelations between the various factors in economic activities'.

They conclude that 'it is tantamount to a call to probe into the strategy for economic and social development of China'.

A review of the experience of the developing countries shows that they have so far gone through three strategies, each one, and improvement over the other.

* The first one is the conventional economic strategy. This is derived from the experience of industrialised nations. This strategy chiefly aims at making a country prosperous and strong by increasing the GNP through industrialisation. The measure often used is per capita income.

* The second one is called 'improved' or 'adopted' economic development strategy, followed by most of the developing countries in the 60's. The chief features of the strategy are, the placing of emphasis on balanced economic development and economic structure; carrying out a 'green revolution'; attaching great weight to population control; attaching importance to self-reliance and development of intellectual resources.

* The third strategy, referred to as the 'new economic development strategy', followed since the 70's by many developing countries, makes a special point of following the realities of the developing countries and meeting the basic needs of the masses. It calls for a yardstick for measuring economic growth, a yardstick which now consists of such indices as literacy, life expectancy and infant mortality. There is no direct reference to 'per capita income' which dominated the scene in the past. The focal point differs greatly from the past.

We must confess that engineering education has not taken serious note of the changes in emphasis made by the Planning commission in the various Five Year Plans. We increased linearly the quantity of intake or the number of institutions and when it came to quality, we followed the West almost mechanically. It is no wonder that some of the best of our graduates find that their education and training find more use in an advanced country and are not relevant in any job situation that they find themselves in, in this country.

Education and economic development in India have been moving on parallel lines, with no great interaction to relate one to the other. The need has been felt, stressed, but no tangible co-ordination has been brought about.

The major point that I may stress in the field of engineering education is the fact that, it is the joint responsibility of the 'educational institutions'anc 'employers'. It is my considered opinion that:

* the academics alone cannot develop a comprehensive educational and training programme that would reflect the existing and emerging needs of the economy and meet the manpower requirement on short and long term basis.

* the educational campuses cannot provide within their boundaries the entire infrastructure and instructional facility needed to educate and train an engineering/ technology graduate who would meet atleast broadly the needs of the economy.

Engineering consists of basic sciences, analysis, design, construction, operation and maintenance. While the first three may be fairly universal, the last three are regional in character. They involve scale of operation, materials used, manpower available and economic organisation. These aspects in general cannot be covered fully by the academics and the preparation needed cannot be accomplished within the educational institutions. The participation of the practitioners and the facility of the field situation are needed.

With the best of facilities and the most talented of academics, an institution cannot prepare an engineering graduate who would be immediately employable without a period of apprenticeship, short or long. Relevance has to be interpreted in proper perspective. It means, content, emphasis, direction, orientation, exposure and appropriate combination of knowledge and skill. It does not mean crippling the dimension of a learned profession and reducing it to a glorified crafts training. The more we go into the issues of engineering education and training, the more we realise the need for, broader foundation in basic sciences, adequate preparation in analytical techniques,appreciation for generalisation, training in application of knowledge to a given problem and the capacity for self learning. These are necessary for one to maintain competence in a professional field where obsolescence rate is high and new materials and methods move in quick succession.

I do not mean to be critical, but would like to state what I consider a matter of fact. The world of employers has not been involved in any significant way in the process and problems of engineering education. It has remained a spectator, a critic and not a partner, and without the partnership of the employers, the kind of fransforrnation needed in engineering education cannot be brought out.

We do come across a strong condemnation of higher education by almost everyone - the political leader, the administrator, the parent, and what is worse, by the teachers and students. No one seems to own responsibility for a gigantic structure that we have built. Condemnation is not a contribution; it is not even a constructive suggestion. We have developed in this country a culture of denouncing what exists without taking the responsibility for finding viable alternatives. That way we may damage without repairing or replacing. With full knowledge of and accepting unreservedly, the weaknesses and inadequacies in our educational system, I may say that we have built an imposing edifice of higher education, though our achievement in the literacy front has unfortunately been poor. We have now scientific and technological capability and manpower resources that resemble a huge reservoir.

The main canals are to be established and above all, the land to benefit the reservoir storage has to be prepared.

The job that remains to be done is, relating what we know, what we learn, and what we find, to the needs and growing demands of the nation, perceived in entirety. This is a task that cannot be accomplished by the academics alone. We need effort that should take the dimensions of a movement, which is possible only with the participation of those sections of the public that matter. Higher education in general and engineering education in particular has reached a stage when it can abosorb and benefit by, inputs from all those who have concern for and stake in, the system.

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'Water is Life' as understood in Spiritualism, Science and Engineering

Shri V B Patel, *Fellow*

Chairman,
Central Water Commission

Mr President, other colleagues within and outside my profession, ladies and gentlemen,

At the outset, I feel it is my duty to express my gratitude to the President and Council of the Institution of Engineers (India) for bestowing upon me this honour to deliver this 25th Nidhu Bhushan Memorial Lecture before a galaxy of intelligentsia in the country. When I received the communication from the Secretary and Director-General of the Institution giving the background of the Nidhu Bhushan Memorial Lecture and urging me to accept the invitation to deliver the 25th Lecture under the series, it immediately came to my mind the dictum given by Shri Adi Sankaracharya in his famous Dakshinamurty Stotram. Adi Sankara, the Advaita Philospher, said, I quotea.

तेनास्य श्रवणात्तढ़र्थमननाद्ध्यानाच्च संकीर्तनात् ।

(Hearing, reciting, meditation and discussion are the steps of learning a subject).

The student learns from the teacher by listening, ie, श्रवणात्. He then recites keeping in mind the implied meaning as told by the teacher — तदर्थमननात्. The student then ponders over it by concentrating or meditating upon what the teacher has taught and what the student has grasped the meaning thereof, ध्यानात्. This meditation the student will get the refinement of the meaning in its various facets. It is at this stage of learning, -the student is likely to get confused and to come out with various conclusions-good, bad or indifferent. 'No, No, what the teacher told may have been good or applicable for his time and circumstances. They are not good for the day, in the circumstances in which I am now living'. In such a case, the student may become a revolutionary, thinking in terms of changing whatever was told in the past, whatever was practised in the past. Change for the change sake is not desirable. Or in other case with a blind following, the student may say that what the teacher had told must be correct and must be followed irrespective of the changed circumstances and he may become a blind follower of conservative methods, even if they are not applicable in the changing times. Such a thing occurs if one has blind following and such attitude is necessarily to be questioned. Therefore, Adi Sankara gives the fourth step of learning, ie संकीर्तनात् . By this I have understood that the lesson that one has learnt, be discussed with others. When others listen to one's views, others would point out the mistakes or mistaken notions that one has imbibed. One's mistakes are not visualised by oneself. Holding of such lecture series and inviting people from various fields of research, education, profession and administration to deliver the lecture on the subject of their choice is, in essence, a chance given to the speaker, to place what he has learnt so far, before, others and get the benefit of their critical reaction, for further refinement of his learning of the subject. I consider that this Nidhu Bhushan Memorial Lecture series, in which I am now the 25th speaker, is in that direction, to give the benefit to the speaker to refine his learning of the subject of his choice (संकीर्तन) . In this sense, I admit, I have selfish motive in accepting the invitation to' deliver this lecture. In the present lecture that I am to deliver before you all, my main intention is to get refinement of my understanding of the subject of lecture and get corrected if I am still holding some wrong notions of the subject. I have learnt the subject from various teachers-anybody who is making me more and more intelligent in the subject is my teacher — आ नो भद्राः क्रतवो यन्तु विश्वतः — let noble thoughts come to us from all quarters of the world. I have thought of the subject, meditated upon it and have been practising in my profession. The present lecture is the outcome of this learning from various quarters. I would request you all to indicate if I slip on any of the aspects of the subject which I am going to deliver now.

The communication, received by me, from the Institution of Engineers, inviting me to deliver this lecture, indicated that the topic of the lecture be chosen from the area of spiritualism, science and engineering. I could not know for myself if these three are different areas of knowledge. What I have understood so far from these terms are: (i) 'spiritualism' is that knowledge by which the enquirer makes the basic enquiry into 'existence' (सत्) and 'non-existence' (असत्); (ii) 'science' is the extension of this knowledge 'by which the enquirer enquires into the properties and composition of the existing material world; and (iii) 'engineering' is this 'science' extended to day-today life, ie, 'applied science'. The same knowledge appears in three facets depending upon the objective with which the enquirer enquires into the object of enquiry, 'limited' or 'unlimited' enquiry. I venture to compare these three terms, ie, 'spiritualism', 'science' and 'engineering' with a simple example of expression of three related terms as a 'book', a 'sheet' and a 'page'. A 'page' has no existence of its own without the existence of a 'sheet' and a 'sheet' conveys no sense without being part of a 'book'. 'Book' is the 'whole' which does not have any meaning without its parts of sheets and pages. I compare engineering to a 'page' of a 'book', 'science' to a 'sheet' of a 'book' and 'spiritualism' to the 'whole' book.

SUBJECT OF LECTURE

Today I have selected the subject of my lecture as 'Water is Life' as considered in three facets of knowledge, namely, 'spiritualism', 'science' and 'engineering'. Spiritualism, as, I understand, is making an enquiry into the existence of spirit (आत्मा) with reference to the appearance of material world (जगत्) and their relation. 'I' the Self' (आत्मा) exists because 'I' am thinking, 'I' am doing, 'I' am seeing, 'I' am experiencing, What 'I' am experiencing is this 'material world' (जगत्). What is this material world and what relation has — 'I', this Self with this world, in broad sense, is the enquiry and this enquiry is termed as spiritual enquiry or 'spiritualism'. The entire enquiry in spiritualism is with reference to the origin as 'I' — the subject. The material world is the 'object' of perception and these two (the spirit and matter) have a relation and that relation is the 'action' (कर्म). These are described in spiritualism as भोक्ता (Bhokta) (the subject), भोज्य (Bhojya) (the object) and भोग (Bhoga) (their reiation).

SIGNIFICANCE OF WATER IN SPIRITUAL KNOWLEDGE

This material world as perceived by the spirit-the self ("I") is grouped into five great elements — पंचमहाभूत. It is pertinent to note that, in science, the grouping of matter is done on the basis of properties or composition of materials that they exhibit such as metals-non-metals, organic-inorganic and active-inert. In spiritualism, the grouping of the material world is with reference to the origin of perceiver ('I'-the self). The Self — (आत्मा) — for perception of matter needs instruments - इंद्रिया:. The Self has 14 such instruments, with the grace of which, the Self.

आत्मेन्द्रियमनोयुक्तं भोक्तेत्याहुर्मनीषिणः ।।

perceives and acts upon the material world. Five instruments are called instruments of knowledge (ज्ञानेंद्रिय) with the grace of which the knowledge or data about material world in terms of form (रूप), taste (रस), smell (गंध), description (शब्द) and touch (स्पर्श) is collected. Four internal instruments (अंत: करणेंद्रिय) asist the Self in analysis of data collected by the instruments of knowledge. After this analysis, five instruments of action (कर्मेंद्रिय) will act. This system, if I venture to compare in the present day working system of computer age-the data input into the computer (the work of ज्ञानेंद्रिय), the internal program of the computer (the work of अंत:करणेंद्रिय) and the print-out (the work of कर्मेंद्रिय). Instruments of knowledge collect data about the world, internal instruments analyse data so collected and the instrumerrts of action exhibit what was collected, what was analysed in the form of action.

Now the material world was grouped into five elements not depending upon their properties, but depending upon the number of instruments of knowledge that the 'self' is required to employ to collect full positive knowledge of that material, ie, to understand earth (पृथिवी). 'Self' is required to employ all the five instruments of knowledge, to understand water (आप:) only four are sufficient (the instrument of smell – घ्राणेंद्रिय – does not contribute any additional knowledge), and for fire (अग्नि:) three instruments are sufficient and so on. The space (आकाश) is understood by only one instrument of knowledge, ie, instrument of hearing (कर्णेंद्रिय). We understand space (आकाश) only by listening to its description and the other senses are of no use. Of the five great elements thus grouped, one is 'water' (the subject of this lecture and the subject of my profession in practice).

What is the significance of water in Vedas? I have come across some quotations specially in Upnishads-Vedanta, the concluding portion of the Vedas. It is stated in the Aitareya Upnishad, belonging to the Rigveda — the oldest of the four Vedas — that there was nothing existing except the Atma (Self) and this "Self" thought of creating worlds and created four worlds (i) the outer-most-the super-celestrial region of water (अम्भ:-Ambhah), (ii) the heaven with the celestial lights (मरीची:-Mareecheeh), (iii) the earth of immortals (मरम्-Maram), and (iv) the sub-terranian region of waters (आप:-Aapah). It is interesting to note that two of the four worlds thus created in the beginning, have their names relating to 'water'. The outermost world, as if enveloping all the other three worlds, is of 'water' and the inner-most world which suggests as if the other three worlds sprang from it, is also of 'water'. Thus, the importance or significance of water in this Vedic times as understood can be easily visualised. This significance of water has further been extended in the creation of the Purusha (the living beings

— the guardians of the worlds) and the creation of food (अन्न) for living beings. I venture to quote from the same Upnishad, ie, Aitareya Upnishad, about the creation or projection of the Purusha as described therein.

सोऽद्भ्य एवं पुरुषं समुद्धृत्यामूर्छयत् ।

(He then raised the 'Purusha' from 'waters' (five elements) and fashioned him). Some interpreters gave the meaning as five elements for the word अद्भ्यः. The ward अद्भ्यः itself literally means 'from out of water'. Use of the word अद्भ्यः for all the 'great elements' is suggestive of the importance/significance of water in creation of the Purusha.

Now, how the food for the Purusa-the guardians of the worlds-is said to have been created? The same Upnishad further continues to indicate,

सोऽपोऽभ्यतपत्ताभ्योऽभितप्ताभ्यो मूर्तिरजायत ।
या वै सा मूर्तिरजायतान्नं वै तत् ।

(He brooded over the waters; and from the waters thus brooded over sprang up the form, or organic matter. And now the form thus born was verily the (treated food). I learn from these quotations that, it was "Water" that was the basis of these worlds, the basis of creation of the guardians of the worlds and the food for the guardians, ie, living beings. From these I may venture to say there is nothing more important or more significant than "water" so far as this world is concerned. It may be clear from this that even during the Vedic times, it was concluded that without 'water' there could be 'nothing'. If we perceive any thing that exists, it must be existing with the grace of this 'water.'

Another aspect for concluding the importance/significance of 'water' in man's life is from the attribution of various names to it. We give a name to a partioular entity depending upon its use, its behaviour or a relation we have. A woman is called a 'daughter' by her parents, a 'mother' by her children, a 'wife' by her husband, an 'enemy' by her enemies, a 'friend' by her friends, and so on, because of exhibiting her character differently. The Lord Vishnu has been attributed thousand names as in Vishnu-Sahasranama.

Names that an entity has, is an indication of its exhibition in various forms and its importance in various uses. Of the five great elements, Earth — पृथिवी — and Water आपः have 27 names each in Sanskrit language — the language of Vedic knowledge. Fire — अग्निः — has 34 names and Air — वायुः and Space — आकाशः — have 20 and 16 names, respectively. While all these elements (material world) are important for life of living beings, the words atributed to 'water' outshine the significance of water in man's life. I venture to quote some such names. अमृतम् — immortality, जीवनम् — Life भुवनम् — the abode, वनम् — Green surroundings, क्षीरम् — the nascent food, कमलम् — Auspecious Lotus-the seat of wealth; सर्वतोमुखम् — having face in all directions. Earth has names to indicate unmoving- stagnant, like अचला, स्थिरा, धरा. वसुधा, वसुन्धरा, etc.

Names of Fire indicate consumption-destruction, like वैश्वानरः, ज्वलनः, पावकः, etc.

From this, I am of the opinion, if I am allowed to say in a lighter vein-'earth' and 'fire' are more useful at the end of man's life, ie, a place and means for cremation, but during life, 'Water' - आपः - also called जीवनम्' significant — 'Water is Life.'.

I get a feeling that some of you, who are more well versed with the scriptural knowledge, are likely to almost accuse me of quoting that portion of the scriptures that hold the element of 'Water' in high esteem. But that is how every man got a different meaning out of a same sentence depending upon the entity देश (place), काल (time), निमित्त (objective). That is how the concept of इष्टदेवता (God of one's Liking) developed. We hold 'Water' as जल देवता.

SIGNIFICANCE OF WATER IN SCIENCE

Let me now turn to the importance and significance of 'water' in science and its development. I mentioned in the beginning that 'Science' is the 'enquiry' into the existing material world, in respect of its composition, its behaviour, etc. It is stated in the spiritual knowledge (scriptures) that this matter has an apparent existence and its appearance is with reference to some origin and that origin is 'Self.' In the present day scientific knowledge of names and forms (नाम रूप) (through material gold is the same, its existence is apparent in various forms of ornaments and the names attached thereto) description of any matter has to have some entity that is required to compare with as a reference point. When we say ice is cold, we necessarily have to have something which is not cold as water or which is hot as steam. Without the knowledge of heat, expression of cold cannot convey any sense. Scientific enquiry into the properties, composition and behaviour of material entities also need some commonly known material to compare' with as a reference. The basic material for comparison has to be taken for granted as a known entity universally. Water is this material which has been taken in scientific enquiry as a base for expressing density in terms of specific gravity. May be, it is the most commonly available material of which everyone is taken for granted to have the pre-knowledge and therefore it has been taken as a base. But it is fact to indicate the significance of water in the scientific enquiry.

Again, it is the water that is the most common solvent used in scientific experiments. It is also used as a common material in majority of experiments. Archimedes — the great Scientist of the early ages-got enlightened to solve his problem when he got dipped into water. I am not sure, if I am right to ay, that this Archimedes' principle would not have come out if there had been no water. Celcius marks, his instruments of measurement of temperature (thermometer) with reference to the freezing and boiling points of water. Unit of heat measurement-calorie is based on the property of water of requirement of heat to raise the temperature of one unit of wafer by one unit of temperature measurement (degree).

Today, if we prohibit the use of water in scientific analysis of material world, I cannot imagine its effect on the development of scientific knowledge. 'Water is life' for scientific knowledge of this material world.

SIGNIFICANCE OF WATER IN ENGINEERING

I have already said that engineering is the 'applied science' or making use of scientific knowledge of matter in practice for the benefit of humanity. I am at loss to imagine the developmental activities without use of water.' Water is the most common input in almost all the developmental works, be it a building or a road or production on farm or in a factory or any other developmental activity. Water is used in agriculture to produce food and fibre **(रोटी)** or it may be the factory to produce other items of necessity like cloth (कपड़ा) or building construction activity for the shelter (मकान) or that of other necessities or luxuries. Without water there could be no growth. Water is the agent for material conversion of inorganic matter into organic matter through plants.

WATER RESOURCES IN THE COUNTRY

I am a Civil Engineer, 'Civil' I mean in both the senses, a branch of engineering and 'civil' in the sense of not 'uncivil.' Within the civil engineering branch, I have chosen my profession in the field dealing with water resources and its development. This subject deals with assessment of water resources, its development for utilization for various purposes and interaction of water between land and water like the problems of waterlogging, sea erosion, river bank erosion or flood control, etc.

Availability of water in our country and its development for utilisation has been the concern of mankind since some time past. Man has been using water for his benefit. Because of its being a daily necessity man settled where water was available nearby. That is how civilisation came up on the banks of rivers. In the earlier days, man did not have the necessity to oonsider the economic use of water as the availability was more than his requirement. Our forefathers did not feel the shortage of water. Population has been increasing and social development has been taking place at a fast rate. Because of this, the requirement of water has been increasing, while its availability which depends upon nature-has remained the same. Today, our estimated requirements are far more than the estimated availability of water for use. This situation reminds me of a saying that 'Man is supposed to be a student throughout his life. He has to learn a lesson every day. The day he does not learn the lesson, some one will teach him a lesson'. The advice implied in this saying was, it is better to learn a lesson-as it will be a willing learning, than to be taught a lesson-as the learning will then be a forced and coercive one. Unfortunately, in the field of water resources, we did not learn a lesson and therefore are now being taught a lesson almost every day and every summer.

LESSONS WE DID NOT LEARN

I have made some efforts to enquire into the reasons why we are placed in such a position today in the field of water resources. One of main drawbacks in our present utilization of water has been indiscriminate commitment of use for sectors of non-priority or low priority.

अतिपरिचयादवज्ञा संततगमनादनादरो भवति ।
मलये भिल्लपुरंध्रि चंदनतरुकाष्टमिधनं कुरुते ।।

We disregard the guest who comes to us more often or do not understand the value of a material that is available in abundance and does not need much effort to acquire it. Since water is a free gift of nature and comes to us without any effort, we just do not care for its importance. Water falls on our head from the rains or is available below our feet underground or in the nearly stream. In early days, our requirement of water was less and availability was in abundance as compared to the requirement. We did not consider allocation of water for priority sectors. Availability continued to remain the same as the natural conditions for more rainfall have not changed nor could be changed artificially. The requirement of water due to developmental works and growing population increased manifold. Rapid development in agriculture technology and use of chemical fertilisers increased the requirement of water for irrigation for the same area of cultivation. Improvement in the man's living conditions needed more water for domestic life. No body was staking a claim on the available water as 'this is ours' and 'that is yours', etc. There were hardly any water disputes among the States in the past. Today, every State has a water dispute with one or the other State. Rajasthan expresses a claim in the, Ganga waters. Tamil Nadu requires water for Madras city from Krishna River. Delhi city, though situated on the banks of Yamuna — a perennial river — needs and is getting water for domestic water supply from Sutlej River (Bhakra Reservoir) and from Ganga (from Upper Ganga Canal). It would need supplementation from new dams. It was not that the river Yamuna has insufficient water to meet the domestic supply of Delhi, but the water is being diverted in the upstream at Tajewala headworks for irrigation in Haryana and Uttar Pradesh. While planning the Yamuna irrigation system by Western Yamuna Canal in Haryana and Eastern Yamuna Canal in Uttar Pradesh, we did not consider the future requirement of Delhi city. May be that we did not visualise so much of growth of Delhi then. Irrigation system has been in existence for decades. It has not been possible and may not be possible, politically and socially, to withdraw this water from the existing irrigation and allow it to go to Delhi to meet the domestic water supply of Delhi. With such short sighted planning in the past, we are now being taught a lesson. Many of you may have known the pinch of water shortage in Delhi in the summer of 1988. Now we have been forced to learn and are therefore making efforts to correct ourselvesfor the future.

IRRIGATION

Because of abundant availability of water and misnomer in the minds, of traditional Indian farmers that mare water to the plants give mare production-yield, abuse or misuse of water took place. Same areas of old irrigation systems and even some new ones have developed problems of waterlogging and are becoming even unfit far cultivation. To remove waterlogging conditions, additional investment to drain the area will have to be made. Agriculture departments have been making efforts in educating the farmers about the need for optimum use of water far higher crop yield. The Water Resources Departments have been assisting the State Governments in their Command Area Development Programmes to maximize the agriculture produce with available water resources, Some of the water resources projects which were held up far want of resolution of inter-state water disputes have also been taken up like Rajghat Dam Project on Betwa River or the Bansagar Project on Sane River.

FLOOD CONTROL

It has not been possible for man to fight and can quernature. Since our water resources development works deal with the nature and its vagaries, man will have to adjust himself with nature along with its vagaries sa as to have minimum loss and maximum benefit. The river daes not need the full width of its flow area all the times during the year or all the years. If man with his developmental activities encroaches upon the river section or the river flow area which is commonly known as flood plain, and when the river needs its awn area of flow far discharging the water that it receives from the catchment, he will come in trouble and may loss whatever he had gained in the past by encroaching upan the river section — flood plain. In other wards, if man occupies the flood plain, he is bound to be affected by floods one day or the other and all the gains that he had achieved by occupying the flood plains would be lost by one flood of the river. The sum total of lass and gain by encroaching upon the flood plain is zero, the only difference that would be-my father gained, and I am paying the price now.

Flood loss statistics indicate a rising trend every year. This rise in lass is mainly because of increased developmental activity in the flood plain because of increasing pressure on land requirement and also due to increase in prices of lass. To reduce the flood lass in quantity, one of the accepted methods is by regulation of developmental activity in the flood plain. Demarcation of flood plain for various land uses is necessary and its regulation is to be brought-in by law. Government of India had prepared a model bill of flood plain zoning and sent to State Governments far consideration as the subject is in the State list in the Constitution. Unfortunately, there has not been much progress in this direction probably because of the unwillingness of the States to bring in any such measures far reasons known to them. One of the reasons far this non-achievement of significant progress on flood plain zoning may be because of scarcity of land and population pressure on land use. But we have to continue our concerted effort, otherwise 'one gains, the other loses' would continue.

NEW LESSONS BEING LEARNT

We did not have a Water Policy of national level to prescribe equitable distribution of available resources in the country among various sectors of development and various rtgions of the country. It was only in 1987 we adopted a National Water Policy for development of water resources. Water resources have been recognised now a scarce and precious national resource, ta be planned, developed and conserved as such. This policy also prescribes that the development should be on an integrated and environmentally sound basis keeping in view the needs of various regions of the country. The National Water Policy prescribes the priorities for allocation for various sectors of development. The order of priority as accepted in the Policy is domestic water supply, irrigation, hydro-power, navigation and industrial and other uses. The Policy also gives a guideline that there should be an integrated and multidisciplinary approach to the planning, formulation and implementation of the projects including catchment area treatment and management, environmental and ecological aspects taking into consideration the aspects of rehabilitation of the effected people and the command area development programmes.

WATER RESOURCES DAY CELEBRATION

Since we in the past had abundant supply of water by force of habit we had so far not understood its importance. To bring home in the minds of people at large-the need af economic use of water-a scarce national resource, Govt of India have been publicly celebrating every year 'Water Resources Day' in various parts of the country. We are yet to reach the village level in carrying this message of importance of water in their lives and. educating them in proper use thereof. I hope in the years to come we will be able to cover the entire country when in every village water resources day will be celebrated to educate the children (citizens of tomorrow) to learn from our mistakes and benefit therefrom for tomorrow.

CONCLUSION

I am an engineer by profession in the field of water resources and water has been my subject of study from various angles starting from the beginning to the present day development. I have no doubt in my mind that water is one of the most important subjects of which we take for granted to have known it. But we are yet really to learn many a things of its boons and curses to mankind and to convert the curse into a boon.

Before I conclude, let me recollect that portion of Katha Upanishad, where Yamadharma, the Lord of Death, used the character of ‘Water’ to indicate the ‘Highest’ to Nachiketa.

यथोदकं दुर्गे वृष्टं पर्वतेषु विधावति ।
एवं धर्मान् पृथक् पश्यंस्यानेवानुविधावति ।।

यथोदकं शुद्धे शुद्धमासिक्तं तादृगेव भवति ।
एवं मुनेर्विजानत आत्मा भवति गौतम ।।

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Technology and Social Change: Some Areas of Conflict

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I consider it a matter of honour, being asked by the President and Council of the Institution of Engineers (India), to deliver this 26th Nidhu Bhusan Memorial Lecture before you. I was surprised on beinqchosen to perform this task in spite of my acknowledged unfamiliarity with the practicalities of technology. I am not a technologist and, therefore, may not be expected to possess ,more than a commonplace understanding about modern technologies, like television; video, computers, robots, rockets, nuclear energy, etc, and how these work. However, being a social scientist by training, I know that these affect society in many different, but important ways. In my world of interest, technology emerges as an important theme, not alone, but only in conjunction with the society. On this theme, I propose to reflect upon. The subject is wide ranging and diffused and, therefore, difficult to come to grip with.

Much of what we have learnt about technology and social change is descriptive. For example, we often refer to the way a part of the vegetational kingdom was domesticated many thousands of years ago to lay the foundation of agriculture. The technique has been adopted, elaborated upon and refined by almost all societies to suit their respective circumstances. This has assured the progress of civilization. So have been the contributions from domestication of a part of the animal kingdom from the invention of the wheel, from the technology of metal extraction, from the use of fossil fuels as also from the eighteenth century Industrial Revolution. All of these were no doubt as fundamental and thorough going for their tlmes asare the experiences on the impacts of telegraph, telephone, radio, television, fax-machines, etc, today.

Arguments on technology and social change have also been tailored to the short-term needs of private organizations or public institutions. Arguments for railways in preference to waterways as means of communication in the nineteenth century India is not too distant an example. As examples from present day India, we may mention the arguments advanced for imports of technology, which private investors took advantage of to flood the country with a large range of softdrinks, biscuits, sweets, processed food, etc. All these have contributed to private gains as also to the growth of national income and employment. The declslon of the government to place at least one television in every village and satellite link-up to cater information as widely as possible is another argument for technology innovation, which may have subserved the Interests of the public policy makers.

Information revolution and proliferation of the inventory of consumable goods are bound to touch every mind in our society. Therefore, not all of us have taken these public and private decisions too kindly. This is an important feature of our time. What distinguishes our time from any in the past is less the general understanding of the fact that technology has important social consequences than our growing awareness and our intensifying desire to deal with it.

I, however, believe that without explicating the mechanisms by which technological innovation lead to changes in society can it be possible to deal effectively with either technology or its social consequences. We need to trace the cause and effect relationship between technology and social change. Needless to mention that our I..mderstanding about such mechanism(s) is yet unclear. To the extent my belief is true, there is much work still to be done and the technologists can contribute a great deal in this endeavour. With this expectation in mind, I propose to share some of the manifestations ofthe mechanism as appearing before us and what we have so far leamt. By putting together our acquired understanding in this regard, I hope, further thought and study will be stimulated to enable us to come to grips with the interface between technology and society.

My argument in brief is that new tools offer newer types of choices and create opportunities to achieve new goals or to do things in new ways. To take advantages of the opportunities, people of groups of people generally must organize themselves differently from before. Such reorganizations are the manifestations of social change. We are concerned with such social changes because these imply that older goals are often given up or given less emphasis in favour of new ones. These also suggest that aJ the moments of technology innovation certain beliefs are subjected to strain.

We may recognize that strains upon belief has to have two locations. In the first instance, such strains are to be found between old values and new technoloqres that somehow do not 'fit' with each other. For example, free availability of condoms may not honour the value that an individual may wish to place on virginity. Secondly, such strains are also to be found between different groups of people. Some of them prefer the old values, goals, and techniques. Some others are willing to give up the old because they fin.d preferred goals or profit or power in new techniques. It is just such strains, suspended between the social groups and their members, that account for much of the passionate agitation that major technological changes usually occasion. These stimulate economic, political, and ideological conflicts.

At the core of all such conflicts are nested a few moral questions about the 'proper' goals of society and the 'proper' ways of pursuing those goals. Many alternative views may be aired by the agitators; but the rationale of opting between these may not be forthcoming. The polity, if not the comity, has to debate upon the moral issues and to get involved to resolve the conflicts. In the process, we may come to learn that technological Innovations also require social and political innovations if its benefits are to be fully realized and its negative effects kspt to a minimum. Here the term 'political' is broadly assumed to include economic and ideological considerations as also the prospects of redesigning political organizations and their tactics.

The effects of technology on society are thus much more complex and demand much deeper knowledge and understanding than is suggested by the popular views about technology. These views may be fashionable, even contrasting. But these tend to oversimplify and are often biased. However, it is natural to happen when relatively little is known about the phenomenon and when the level of discourse is not high. Neverthelessthese views are important; because by evaluating these our understanding about the phenomenon may reach a higher level.

There are some amongst us now in India who consider technology as an unalloyed blessing for man and society. They wish to tell us that technology is the motor of all progress, holding solutions for most of our social problems, and capable of liberating the individual from the clutches of a tradition bound society. They believe that man is fully in command of his tools and destiny, or should be if he is not. They assume a model of society in which science is the principal determining element. This view tends to be held by many scientists and engineers, by many military leaders, and by many devotees of 'scientific management' as systems analysis and programme planning imply. They are the optimists.

There is also a contrary view now in India that sees technology as an almost unmitigated curse. They tend to believe that technology robs people of their jobs, their privacy, their participation in democracy, and of their dignity as human beings. Technology to them appears as fostering materialistic values, as destructive of religion, as the harbinger of a technocratic society and bureaucratic state, and as capable of poisoning nature and blowing up the world. Technology is seen as autonomous and uncontrollable. They are the pessimists.

Both the views are supported by a good deal of empirical evidences, which makes choice a harder proposition for the uncommitted. The incredulous amongst us tend to detect, below the surface of the optimistic view, the traces of economic and political ideology propounded by some vested interests for profit and power. Similarly, below the surface of the pessimistic view, they detect the presence of the segments of the population that suffer distocation as a result of technological change and who hold 'back-to-nature' attitudes towards the world.

The contrasts between the views of the optimists and the pessimists make the incredulous aware of the psychological, sociological, political, and economic attributes of society. They also realize that these contrasts require them to deal with those who have power and status and those who do not. Disposition of the society to handle this struggle between the powerful and the weak thus becomes the major concern in technology innovation.

There are, however, some amongst us who consider that technology innovation is not at all a new experience for the society to deal with, It has' always been recognized as a factor in social change, though the pace of change has been rather rapid since the eighteenth century Industrial Revolution. Nevertheless, improved communications and higher levels of education have continually made the people more adaptable to new ideas and to' new social reforms required by technology. In their understanding, man's social and psychological development has been roughly in equilibrium with the scope and rate of technological change.

This third view tends to be held by those for whom continuity is an indispensable methodological assumption, such as the historians. To them, the idea of survival of society appears as an unquestionable belief, as something worth laying faith upon. Such a view is also held by those who would rather ignore a situation that rlpfies quantification by the techniques of measurement available with them. An inexact and undefinable object, to them, is not worthy of critical involvement. In the process, they deny themselves the privilege of gaining better knowledge about the mechanism by which technology leads to social change or better insight about the implication of technology for the future.

The foregoing review of the three major types of ideas on technology and social change, though brief, reveals their comparative merits. The strength of the third view lies in its recognition of social origins of technology. But it does not adequately explore the role of social institutions mediating between technology and its effects.

The social setting into which technology is introduced has much to do with whether, to what degree, in what ways, and which ones of the benefits potential in technology will be realised.

By way of an example, we may consider the effects of gravity flow irrigation technology when introduced in the drought prone areas of southern India. Here the farmers were accustomed to raise low water demanding crops as rainfall was poor compared to many other parts of India. Seasonal as well as annual variations of rainfall are also very high. The idea of gravity flow irrigation technology supported by reservoirs appeared as appropriate to smoothen the harsh edges of variations of rainfall. It was decided not to encourage substitution of the existing cropping pattern by high water demanding crops to let the impounded water of the reservoirs cover the widest possible command area. It was decided to compensate the farmers displaced to make room for the chosen infrastructure with land in areas of most assured irrigation. To meet the'short-fall'in local labour, contractors were encouraged to recruit workmen from the more densely peopled areas of coastal south India. The idea was to lay the designed infrastructure as quickly as funds permitted.

It was, however, not anticipated that the rehabilitated farmers would.sell-off the land given as compensation for want of knowledge in wet-farming methods. Nor was it anticipated that the labour-contractors would abandon the labour force after implementation of projects. Many of these so abandoned people, instead of returning home, found it advantageous to buy land within the new command areas with the money derived from sale of land in their villages of origin. They could acquire larger farms since the price of land in coastal south India was higher than that in the drought prone tracts. National policy on price of sugar stimulated the farmers to opt for sugar-cane cultivation, a high water demanding crop, within the command area. In the process, the effective command area shrank in size and covered only a small part of that originally designed.

None of these instances of departure from the original intent of the projects can be described as products of irrational motivation. The social setting into which the technology was introduced provided the motivation and rationality for parts of the society to keep enjoyment of the radical beneficial possibility for themselves and to restrain the others from getting those. The given technology offered alternative choices and the society refrained from valueing between those options. As a result, the consequences of technology innovation was allowed to fall where they did.

Instances of having failed to exercise social choices between opportunities offered by technolcgy are many in our contemporary society. Many of us recognize the exciting possibulties andtonq term-promises of experiments with computers, and teaching machines in our educational institutions. Some ot these promises have been realized in the autonomous institutions of education, but not at the level of schools. Knowledge about how to apply the new machines in education, to say the least, is primitive. Teaching methods and curriculum contents have remained virtually unmodified partly because of lack of imagination '-'f the educators and partly due to resistance offered by the structure of educational administration. The Indian school system is held by inflexible curriculum defended by unmovable bureaucracy. The loosely held instructors find their initiative yielding easier profit if directed in the line of small business than to demand autonomy in educational administration. Therefore, the machines are gathering dust, after the initial enthusiasm subsided, in most of our schools. The instances of exception are given by such institutions where the instructors have agreed to act as autonomous 'decision makers. The lesson to draw is obvious. Technology may be the motor of progress, but institutional sluggishness will most often turn out to be a very effective brake.

The two examples given above do not embrace the universe of technological impacts upon society. Sometime, the very value premises upon which our social systems are based get severely eroded by the effects of technology intnovation. Development of mass communication technology provides the best example in this regard. It has given great benefits for education, journalism, and commerce. It has also been responsible for raising expectations faster than our political systems can accommodate. A youth of our time can find out what the world is really like from the television before home and school have the time to instill some ethical sense of what it should or could be like, before he can learn what values the social ideals and norms reflect, and before he has the knowledge of history, contemporary fact, and future possibilities to support sound judgment and meaningful action. All these carry the potentials of turning him to rebellion with typically anti intellectual and anarchistic stances.

The received norms will be increasingly subjected to questioning and reformulation in a society in which the store of knowledge about the consequences of action is large and is rapidly increasing. This is true for all technologically advanced societies where technological possibilities continue to lie fallow, the appeal of the received norms continue and its justification is often invoked. For this reason, many commentators on social history consider technological innovation as a process that is 'devoted' to an end of ideology. This may be one of the reasons why highly doctrinaire radicalism of the earlier years find few followers amongst the intelligent youth of our time.

Erosion of doctrinaire thoughts does not leave religion untouched. Religion for societies functions as a super-ordinate belief system that provides legitimation to moral and social valuEjs. It imparts meaning to social existence within the notions of eternity. Traditional religious postures, therefore, produce symbolisms like destiny, fatefulness, and subservience to supranatural mystery of cosmology and order therein. But these symbolisms lose credibility as men begin to experience, through the use of technology, their power and their relationship to nature and history in terms of open possibility, hope, action, and selfconfidence. No religion can hope to be influential that ignore this parallel experience of mankind.

With the improvements in communication technology, we have come to learn a good deal about how different religions function in different societies. Our increasing knowledge of other peoples social and religious diversity seem less unnatural and more acceptable than was the case a century ago, say. This provides the base for emergence of secular belief systems to complete for allegiance of men.

Please note that I have described secularism as a belief system. Therefore, it need not be seen as to negate the basic precept of religion. What it does is reject divinity in favour of alternative objects of faith, like atheism, agnosticism, the ethics of science, etc. These new objects of faith generally emerge simultaneously to produce pluralism of belief systems concerned with the perceptions of the future.

This pluralism of belief systems poses serious problems for the earlier forms of legitimation of moral and social values that traditional religions seek to provide. It demands a form of synthesis that can integrate the fact of variant perspectives into the traditional symbol system. Fojlowers of traditional religions with doctrinaire accent have unfortunately taken the route of condemnation of variance as heresy. Under attack, they have turned fundamentalists.

What consequences would such new objects of faith have for values is question, I cannot answer. But I believe.that resolution is likely to emerge from the choice that the traditonal religions make between their perceptions of the future or eternity. It is important that we think CNer the issue seriously because there are three major traditions inherent in all major religions bearing upon the meaning or perspective that these attach to etemity or future of mankind. The maxims of a new religion will emerge from the way we decide to deal with these traditions.

In the first instance, there is the 'teleological' tradition in ancient religions that sees the future as the certain unfolding of a fixed purpose inherent in the cosmogony itself. The proponents of the first or the 'optimistic' view on technology that we have mentioned in the beginning are likely to support this teleological tradition.

Then, there is the 'apocalyptic' tradition in ancient religions that foresees imminent catastrophe and stimulates a negative evaluation of the experiences encountered in today's world. It is likely that the proponents of the second or the 'pessimistic' view on technology will draw sustenance from this apocalyptic tradition.

Finally, there is the 'prophetic' tradition in almost all ancient religions that wishes to look upon the future as an open field of human hope and responsibility. In other words, the future would become what man will make of it. This comes closest to that view in technology which considers it as a creator of new oossibilities but leaves their disposition uncertain. What its effects will be and what ends will it serve are not inherent in the technology, but depend on what man will do with technology. Therefore, the prophetic tradition may provide us with a context for new synthesis that is adequate to our experience and continuous with what is most relevant in our religious history.

This may not, however, lead us to deny the role that values play in shaping the course of society and decisions of Individuals. In fact, questions of value become more pointed and insistent in a society that has a large store of knowledge on the consequences of technological action and that has organized itself to control technology through deliberate social planning. Such insistence has required the planners of economic development and social change to make explicit their value commitments and value priorities. The process often brings into the open the conflicts of values that otherwise remain hidden in the more impersonal and less conscious workings of the market system. These events demonstrate that the technologically advanced societies may have gone against 'received ideologies', but have not necessarily relinquished their rights to 'preferred values'.

Societies, such as ours, that have decided to promote technology innovation as a part of social planning may learn a great deal by examining the sets of values that are emerging and are being debated upon in the technologically advanced countries. However, we shall do well to recognize that not all their preferred values could be replicated in contemporary India.

This note of caution I am raising only to help recognize the fact that technological possibility continues to lie fallow over most parts of our terrain involving the majority of our people. Knowledge on the consequences of technological action upon such fallow terrains and hitherto uninitiated majority in our society is rather poor. Whatever there is of this knowledge is confined within a thin segment of our society. The first and foremost task of this segment of our society is to enrich their knowledge through praxis within the very arena of technology innovation. I do not have any prescription to offer with regard to the ways praxeological knowledge can be enriched except to mention a few issues of importance, attention to which may be useful.

I shall first mention some issues which generally reveal themselves within the economy. Then I shall mention some other issues which have deep political implications. Such a partitioning of the issues should be seen as contrived or artificial, because these merge into one another in the arena of political economy.

Technological opportunities within an economy is seen in terms of new machines to reduce cost of production, or new products to sell, or new systems to organize action to accomplish missions. As a rule, these are seen.developed and applied through individual decisions. The decision makers may be the individual entrepreneurs, individual firms, and individual governmental agencies. These are the actors or facilitators of technological innovation.

This individual decision maker calculates the benefit that he expects to derive from the new development and compares it with what it is likely to cost him. Whatever may be the order of complexity encountered in calculating benefit and cost, he will go ahead only when the expected benefit is greater than the cost to be paid for. The procedure is simple and, like all simple paradigms, it hides much more than it reveals. In making the calculations,lhe individual decision maker does not pay very much attention to the probable benefits and costs of development to others than himself, except to the extent that he is required to do so by relevant laws or governmental regulations. He finds his defence in the value that we socially cherish in granting freedom of individual decision making as a means to unfolding the mechanics of market economy.

Unless we consider the deeper implications of the value of freedom of decision making, the benefits potential in new technology and external to his calculations may not at all be realised by the individual developer. The potential external benefits and costs can accrue to society only if deliberate social actions are organized. However, decisions to organize social actions, without impinging upon the cherished value of freedom to technologiaill innovators, may not emerge in a straightforward manner. Newer values are to be invoked to exercise options between alternatives. A few examples may reveal the nature of complexities in decision making in this regard.

We may first consider the opportunities which are potential in the context of diverse costs that technological development entails: These costs would include design and engineering, plant and equipment, raw materials, packaging, distribution, marketing, labour, etc. Around each item,formation of wealth and employrnent for persons other than the developer is possible. These will be available only to that society which takes deliberate social actions to meet the demands of design and engineering, plant and equipment, etc. A given society will fail to get the advantages if it does not organize the necessary social actions.

It should be clear to all of us that every technological development will put demands upon the pre-existing structure of social base of technology to re-organize itself. Some elements of the earlier structure will need to discover its new role as ancillary to the given technological development. Some new elements could emerge through adoption of subsidiary functions. For example, irrigation, fertilizer and pesticide production will be the necessary ancillary functions to oil seeds cultivation. Similarly, oil impellers, soap making, use of oil cakes as cattle feed, milk processing, etc, may emerge as necessary subsidiary activities to oil seeds cultivation. Creation of such new attachments may not be accepted as tasks by the entrepreneur interested in a new technological development like oil seed cultivation in given area. Such formations of ancillaries and subsidiaries must be attended to by the society at large, if it desires to realize the full potentials of technology innovation.

Willingness of the developer of new technology to meet all direct costs may not be a sufficient guarantee against upsets to the society. For example, a paper mill industry in India may take away from the villagers their earlier access to the forest resources. This right of the villagers may be secured in many different ways; for example, by disallowing investment on paper mills, or by importing paper pulp, or by creating newer and richer forest wealth. Each one of such decisions will require different schedules of social actions and the selection of a decision will depend on what values the given society wishes to endorse.

The need for social actions also emerge from the innovators unwillingness to meet certain costs of technological development. It is true that the individual developers pay for all, direct costs. But he does not pay for the waste that he pours into the open, the smoke he discharges into the air, the noise that his plant and equipment make, or the job dislocations that he causes when he automates his plants. He tries to avoid such costs unless restrained by laws and government regulations. The statutes and regulations are but one kind of instrument that society may use to organize social action. The society may, in addition, consider recycling of wastes as a means to produce useful goods. The social actions necessary for recycling will be quite different from those related to administration of preventive laws and regulations.

In short, to realize the full potentials of technology innovation, a society has to deliberate upon alternative values and to opt between those. The same will be needed to contain the negative effects of technology innovation. However, no value can be opted for before its specific as well as general implications upon the society have been examined and debated upon. A society that has chosen the value of democracy will need to organize public examination and publiC debates on the deeper implications of all stated values. And that brings us to the questions on organizing social action by the polity.

Public decisions or public policies are required to take care of the deeper implications of the private decisions on technology adoption. The institutions required to formulate- public policies must encompass all of the decision making structures and procedures that have to do with the allocation and distribution of wealth and power in society. These shall be some thing more than a formal government.

No longer can we take the government as playing simple role of arbiter of conflicting interests between business, labour, farmers, or whatever, or as the agent to whom all social actions should be delegated. Instead, government has to take on the function of social pioneer and leader of a team. It has to identify opportunities and problems over the horizon before they are upon us. It has to marshall the forces, public and private, needed to deal with both. In the process, a mixing-up of social institutions shall be inevitable. To resist this process may mean for a polity to deny itself the advantages of technology and to invite injury from impersonal interplay of innumerable private decisions. A number of considerations lead to such a conclusion.

We may, for example, look at the growing range of public protests against unwanted environmental consequences of technology adoption, where even the formal government playing the role of entrepreneur has not been spared. I see in these protests a growing sign of our society wishing to make social decisions deliberately and in public ways. I also see in these protests the evidences of all types of institutions becoming aware of the increasingly public character of the problems they face. To take advantage of this awareness, government has to play the role of social pioneer and leader of a team.

This role is unavoidable. For example,the physical dispersion and formations of diverse neighbourhoods made possible by transportation and communication technologies tend to enlarge the urban complex that must at the same time be governed as an unit. We have to invite participation of the dispersed and differentiated neighbourhood committees to keep themselves together as a unit. The body politic has to restructure itself to let the spirit of centralism honoured through democratic participation. This may be possible if we develop clearer understanding in three major areas and state our preferred values for public scrutiny.

In the first instance, we have to decide on the quantum of public goods that a society should produce to mitigate the negative effects of technology adoption that generally come from production of private goods. Clean environment is a public goods, which the private firms are not likely to invest upon unless deliberate social actions are organized. However, the organizers of such social actions may not forget that the costs thrust upon private firms to keep environment clean will ultimately be passed on to the consumers of private goods. To help the society to bear the effects, one may consider organizing better conservancy and sanitation services,clean water supply systems, public health-care institutions, etc, all of which are public goods.

The point to note is that some public goods can behave like private goods, such as higher education or specialized health I care service. Some public goods assist in the consumption of private goods, such as roads for the motor cars. Some other public goods have little to do with production of private goods, such as parks and open spaces. Therefore, the decisions on the quantum of public goods get inseparable from the decisions on the types of public goods to be created. Such decisions can be taken only when the society can participate in declaring their preferences deliberately and in public ways.

Secondly, we have to decide on how the pubic decisions will be taken and through what instrumentations. We may not forget that the effects of advanced technology cover large distances in both the geographical and social senses of the term. The imperatives of modern decision making should therefore require greater and greater dependence on collection and analysis of data and on the use of technological devices including scientific methodology. In India, this need has been recognised and many scientific and knowledge agencies have been created, but mostly outside the administrative control of the government.

Within the governmental administration, professional scientists are increasingly inducted into the policy-making process. The broader face of this trend is the increasing use of experts of all sorts in the process of government. But kindly note the problems that this trend implies for the role of a less expert member of the Parliament or Legislative Assemblies and a less expert electorate in public decision making. Probably the solution lies in making transparent disclosure of the considerations behind an expert decision to invoke public participation within a spirit of democratic centralism.

Finally, we have to decide about the degree to which we will function as social beings and the degree to which we will pursue private satisfactions. This is not an issue that can be handled privately. The issue can derive clarity only when we debate publicly the role of an individual within the process of democratic centralism. Through such debates, I believe, many of our old values may get reformulated.

It must certainly be concluded that the power, authority, influence and scope of government are greater today than at any time in the history of mankind. Government today does encroach on dornalns that were once exclusively private, such as through policies on' family planning. The old Athenian society considered it a virtue to permit such encroachment into privacy. Should we also consider it a virtue and let the impersonal bureaucrat impinge upon our personal rights?

It is possible to look upon the modern government somewhat differently. Government today may be more powerful and pervasive than in the past, but it also appears to be more lacking in single minded determination 'than ever before. As people become more educated and self-confident they yield less to, and demand more of, government. They organize themselves and require the government to consult opinion polls, accept criticisms from press and public, and to engage in dialogue with the diverse constituencies. They get to develop self-image and a sense of value as human beings. As a consequence, the scope of individual choice and action today are greater than in previous time.

We exercise our choices on consumer products, marital partners, occupation, place to live, objects of loyalty, and allegiance to religious, political, and other social groups. To the extent the governement is not fully responsive to such rights of the individuals, revolts against authority follows. At the same time, the need for having a pervasive authority or a centralizing system is recognised to enable exercise all the individual choices. Such a reality cannot be tackled by old values on the relationship between individual rights and social responsibility.

I cannot prescribe any new formulas to resolve the issues raised above, except to state my belief that effective citizenship today can be fruitfully conducted only in terms of the nature of cornmitment that individuals are called upon to make. As at once individuals and social beings, we must achieve a symbiotic relationship between our private and public selves by deciding about the degree to which we will function as social beings and the degree to which we will pursue private satisfaction. It is such an ethic that could hold together, I believe, the individual man and the organized society. If there is any old religion that endorses such an ethic, I do not see why its pursuers cannot assume a radical role in imparting meaning to our existence as individuals and social beings simultaneously.

The Twenty-seventh Nidhu Bhusan Memorial Lecture was delivered during the Seventh Indian Engineering Congress, Bangalore, February 15, 1993

Education and Environment — Issues for the 21st Century

Prof D Banerjee, Fellow

Ex-Principal,
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Mr President, members of the Council, honoured guests, my fellow Corporate Members, Technician and Students, ladies and gentlemen, I feel honoured and express my sincere thanks to you, Mr President and the Council, for choosing me as the speaker for the 27th Nidhu Bhusan Memorial Lecture here this morning. I also pay my respectful homage to late Nidhu Bhusan Chatterjee, illustrious father of an outstanding teacher and technologist, who had instituted this Lecturership. I had the good fortune of being very close to late Dr G P Chatterjee, who was devoted to teaching and research in metallurgy and material science and had a strong base of Indian culture and ethics. The institution of the Nidhu Bhusan Memorial Lecturership out of this small contributions is a unique feature in the pursuit of knowledge of science and technology but not divorced from spiritual and moral values. He was an ardent'follower of Indian Education and Culture' and spoke on the subject in different forums including the Institution. The title of the lecture 'Science, Spiritualism and Technology' has been fixed on the basis of his wishes by the Institution of Engineers, with full freedom for developing professional education appropriate to the needs of the profession and the society.

Being an engineer by education and training and a teacher by profession, I was at a dilemma to choose the topic of this lecture with relevance to the theme 'Science, Spiritualism and Technology' and present some food for thought in the current socio-economic turmoil. Although SUbjects like water, energy and environmental pollution have attracted attention of scientists, politicians and the public in general, I am inclined to present my thoughts about technology education in India and the world during the last half a century and the challenges of technical education in the next century.

While going through the list of speakers who have delivered the Nidhu Bhusan Memorial Lecture series before me, I find the Institution Council had chosen mostly teachers out of the 26 lectures delivered so far. I am inclined to conclude that the professional engineers of India have mixed reactions about the growth and development of technological education reactions about the growth and development of technological education and its fulfilment of the objectives relevant to the socio-economic needs of Independent India. I had the good fortune to come in contact with all these outstanding personalities who have been actively associated with education, scientific and technical, in India. Out of these educationists, Dr T Sen had been very actively associated with the development of education in general and techninal education in particular, as a teacher, education reformist, member of Education Commission and, finally, as a Minister in charge of education of the Government of India. My contributions in this field will be only a small element in the vast source of knowledge that has already been documented through the lectures presented by my predecessors to whom I pay my respectful submission.

After a brief review of some of the lectures presented before me I have chosen to speak on 'Education and Environment-Issues for the 21 st Century'. I begin my presentation with a quote from our past President of India, Dr Sarvapalli Radhakrishnan, who in a letter dated July 6, 1962, said, 'The purpose of education is to help us to find out what we are in this world for-is it merely to grow rich or greatly learned or is it for the purpose of fulfilling yourself and making yourself an offering to the Supreme ?'

'The education has certain ends in view. In the present day world, it means giving the pupils a knowledge of the world in which they live; study science, history, geography, etc to enable them to get knowledge; they are also trained to acquire some skills by which they can earn a livelihood'. 'But, however intellectually informed and technically skilled we may be, unless there is sustaining purpose, an overarching vision, knowledge and skill by themselves will not be enough'.

'The Gita emphasizes the need for combining wisdom with knowledge — Jnanam, vijnana-sahitam. Many of our students suffer from a spiritual vacuum. For a balanced education, we need the development of moral standards and spiritual aspirations'.

'According to Indian thought, the purpose of education is not an acquisition of skills and informations only, but to qualify for initiation into higher life, into a realm of thought which transcends the world of space and time, though the Supreme informs and animates it'.

What is wrong with our system?

'The system of education prevalent in our country lacked one thing; apart from the tenents of any particular religion, there are certain moral and spiritual values which are common to all faiths and even those who do not accept such fundamental ideas as of great value. It is, therefore, necessary to give our own people a grounding in such universal moral and spiritual precepts', said Dr Rajendra Prasad, the first President of India.

He continued further, 'We have not only to safeguard our national integrity but also our cultural heritage. The time has come when a synthesis should not only be worked out but propagated between science and spiritualism. On this basis we can build up a society, the members of which can face the menace successfully, without giving up their belief in any faith' 'I would suggest that attempts should be made to devise and formulate a course which can be introduced as part of curriculum of all educational institutions. '

Pandit Jawaharlal Nehru remarked, 'Education, if it is to be worthwhile, has to deal with moral and ethical standards even though it does not teach any specific religion as such. Life cannot be divorced from these ethical problems and from its spiritual aspects, or else, it becomes lopsided'.

'We have seen tremendous advances made by science and technology. Indeed the emblem of the modern world can well be said to be the mushroom cloud which is the product of atom bomb explosion. Unless this advance is balanced by progress in the spirit of man, the world which is near disaster already, may well succumb to it'.

'We cannot do without science, for that is the essential aspect of truth and represents the modern world. At the same time we cannot do without spirituality in our education and makeup. The only way, therefore, is as Vinoba Shave has put it, 'to combine science and spirituality'.

Shri V V Giri, the then Governor of Kerala, expressed his view as follows: 'The fundamental aim of education, in my view, should be to train the students in a disciplined way and to provide them with a purpose in life. A Nation's greatness lies not in mere numbers who are well versed in arts, in science or in technology but in producing citizens, robust in their optimism possessing high sense of integrity and character. Education is initiation into the life of the spirit, a training of human souls in the pursuit of truth and practice of virtue.'

The present day education is rightly criticized for its lack of purpose and its being devoid of higher values of life-moral and spiritual.

Heritage of Educational Frame work

Till the early years of the 19th century, educational system at primary and secondary as well as at higher levels was the continuation of the one which prevailed through the medieval period. Both at the rural and so called urban levels, instruction for literacy and numeracy was imparted to children in pathsa/ayas by the *gurumahaseyas* or in *muktabs/madrassas* by *moulovis*.

Higher education traditionally reared on such a base was, however, stagnant and extremely restricted in the form of lessons in grammar or in rudiments of philosophical enquiry available in tols or chatasputhies by erudite pandlts/scholars.

Such toIs were spread all over the country. In the eastern region of India tols were thickly clustered in places such as Mithila/Darbhanga in north eastern Bihar, the area to the south of the Ganga and on either banks of the Bhagirathi. Some of the renowned old centres of learning in West Bengal were Bhatpara, Nabadwipdham, Tribeni and also around Kalna and Katwa, as well as in places like Howrah, Arambagh, Bishnupur and Midnapur. Education in ancient India was generally aimed at self-realization under the direct supervision and guidance of the Guru in the midst of natural surroundings ofthe Ashrama. An intimate and personal relationship existed between the pupil and the teacher who could inspire them to internal quest of the 'Infinite, by example of his own life and deeds'.

We have travelled a long way from the ancient system of education and the ancient way' of life. The emphasis has shifted from self- realisation to objective knowledge, from mastery of the inner world to the external world.

Moral and Spiritual Education

Man has acquired great mastery over forces of nature by the advancement of science and technology but remains oppressed by the evil of his creation and fear of death. One truth is, however, beginning to dawn that without proper understanding of the self, through spiritual education, man will never get the real sense of security.

In reconstructing or restructuring our educational system, specially in science and technology, we have not done well to cut ourselves off from the roots which also could give us sustenance and strength. It would be a great tragedy if in this pursuit of external knowledge and the so called mastery over the nature and the external world we lose sight of the internal ·world and the sight of the true reality. Spirituality alone can offer this insight and make the world more meaningful and pleasant.

Moral and Spiritual Values in Curriculum

On the advent of independence, provision was made in our draft Constitution permitting religious instructions outside school hours and in clause 22(3), stated as follows:

"Nothing in this article shall prevent any community or denomination from providing religious instruction for pupils of that community or denomination in an educational institution outside its working hours'.

It was, however, left out when the Constitution came to be enacted. The Constituent Assembly drew up the Constitution of Sovereign Democratic Republic (1950) expressed its own decision regarding religious education as follows:

28(1) No religious instruction shall be provided in any educational institution wholly maintained out of State fund.

(2) Nothing in clause(1) shall apply to educational institutions administered by State but has been established under any endowment or trust which requires that religious instruction shall be imparted in such institution.

30(1) All minorities whether based on religion or language, shall have the right to establish and administer educational institutions of their choice.

(2) The State shall not, in granting aid to educational institutions, discriminate any educational institution on the ground that it is under the management of minority, whether based on religion or language.

It is clear from the above that while there would be no instruction in any religion in educational institutions wholly maintained by State funds, the State would continue to administer and assit institutions where religious instructions are imparted under any endowment or trust.

After more than a decade our leaders in Government and outside raised their voice to say that something has gone wrong with our educational institutions and the educational system resulting in indiscipline, rioting and lack of faith in teachers in various parts of the country due to lack of sense of values. They felt the necessity of developing inner discipline and strength of character amongst the youth so that liberty is not debased into licence and that our educational institutions produce young men and women of sound character, discipline, responsible and trustworthy-fit citizens of a free country. Many may have felt that the secular nature of our State had been wrongly interpreted to mean complete freedom from moral restraints, leading to a sad loss of all sense of values.

Another aspect visible in most educational institution campuses was a feeling of frustration in the mtnds of students due to growing menace of unemployment amongst educated youths leading to discontent and lack of discipline which is dislocating the social and academic life.

The Ministry of Education, Government of India, in 1959, appointed a committee under the chairmanship of Shri Sri Prakasa, the then Governor of Bombay, to study the question of religious and moral instruction in educational institutions and, if desirable, to define the content of such instructions at various levels. The committee made the following broad recommendations:

(a) Teaching of moral and spiritual values in educational institutions is desirable and feasible with certain limitations.

(b) The content of such education in moral and spiritual values should include a comparative and sympathetic study of lives and teachings of great religious leaders and at later stages, their ethical systems and philosophies. The inculcation of good manners, social service and true patriotism should be continuously stressed at all stages.

During the last three decades, the growth of education facilities has been remarkable, but the teaching of moral and spiritual values, as recommended, did not take place. The result has been deterioration of academic atmosphere congenial to effective teaching and learning process, disruption of academic programmes, malpractices in examination halls and utter disrespect towards academics and academic system. What is even more disturbing is that scientific and technological professionals without a spiritual base are being utilized as workforce motivated for personnel gains without any obligation to the profession, environment or the society.

Reactions of Scientific Achievement

Wonderful discoveries of material sciences and tremendous progress in engineering and technology over the last half of a century have dazzled the eyes of man and being more and more disillusioned. No doubt, these developments have increased wealth and comfort to the whole human race, but at what cost: lack of peace and harmony, degradation of the 'ecological system and social fabric over the entire world.

In the words of Swami Vivekananda, we may say that 'if achievement of material science has increased prosperity and comfort in arithmetic progression, it has brought in, along with it, discontent and despair in geometric progression. In fact utter heedlessness to spiritual outlook of life has been threatening the world with dire disaster'.

Changing Global Environment

Over the last century or so we have become so powerful with scientific knowledge and technological skills, that we have come to equal and perhaps exceed the powerful forces of nature that for billions of years have shaped the face of the earth and the quality of life on it. But the toll we have exerted in supporting our daily life and technological development and evergrowing numbers of people inhabiting the earth, has been exerting profound pressures on our planet, its environment, other species and ultimately on ourselves as well.

Global warming, acid rain, reduction in biodiversity and ozone depletion, are some of the signals warning us that we must come to terms with destructive effects we have had on the environment. In essence, we have been conducting an uncontrolled experiment with the planet and the results of that experiment are not yet clear. The complex interplay of forces acting on the global environmental system, the likelihood that these problems will persist and intensify for the years to come and the possibility that more environmental surprises than the discovery of the hole in the ozone layer over the Antartica have contributed to the concerns around the world about the future of our global environment.

Human activities are transforming the global environment and these changes have many faces such as tropical deforestation, acid deposition, increased atmospheric concentration of gases and warming the global climate, ozone depletion, etc. For many of the troubling transformations, data and analysis are fragmentary, scientific understanding incomplete, and long term implications are unknown. Yet even against continuing background of uncertainty, it is abandontly clear that human activities of burning of fossil fuels, emitting pollutants from industry and clearing forests that are the habitats of plant and animal species, for example, now match or even surpass natural processes as agents of change in the planetary environment.

'Understanding the nature and possible consequences of global changes is an urgent challenge to natural sciences, social sciences and engineering and to the world community of nations and their citizens', sc said Dr Frank Press, President, National Academy of Sciences, USA. It is important that the spirit of these observation is appreciated by the education planners and reformers and due emphasis given in reorientation of curricula for sciences and enqlneerinq institutions all over the world.

As human race prepares to'venture into a new century, conversations and news reports are peppered with references to our fragile and endangered planet. The earth is five billion years old and over the eons it has endured bombardment by meteors, abrupt shifts in its magnetic fields, dramatic realignment of land masses, and the advance and retreat of , mountains that reshaped its surface. Life, too, has been resilient. In the more than 3.5 billion years since the first forms of life emerged, biological species have come and gone but life has persisted without interruption. In fact no matter what we humans do, it is unlikely that we could surpass the powerful physical and chemical forces that drive the earth system.

Although we cannot completely disrupt the earth system, we do affect it significantly and disrupt the earth system, as we use fossil fuel for energy production and emit pollutants in the quest of food, shelter, clothes and a host of other products for the world's growing population. Science and technology play the most vital role in the quest and playa subjective role in the hands of the political rulers.

The interplay between scientific and technological process and public policy is not new but has been a characteristic of most of the great turning points in human history. One need to look no further than the dawning of the nuclear age to see that Fermi, Bohr, Oppenheimer and Sakharov influenced today's world just as much as Roosevelt, Stalin, Churchill, Gandhi and Hammarskjold did. It may be more important than ever for scientists and technologists to keep the doors of their laboratories open to political, economic and ideological currents. The role of scientists as isolated explorers of the unchartered world of tomorrow must be reconciled with their role as committed, responsible citizens of the unsettled world of today.

Technical Education in India

Technical education represents a complex group of activities that include post-graduate course and research, under graduate course leading to the first degree, diploma and certificate courses, technical studies in secondary schools and junior technical schools, trade courses and even training of skilled craftsmen. One of the important characteristics of technical education is that unlike general education, the curricula should provide for educational development as well as acquisition of knowledge and skill relevant to the industry and society as a whole.

Growth: Earliest record of establishment of technical institutions in India is the institute at Guindy, Madras, followed by the Thomason College at Roorkee, Engineering Colleges at Poona and Shibpore, VJTI. Bombay and Kalabhavan, Baroda. During the present century, CET, Jadavpur, IISc, Bangalore, and Engineering College at BHU were established during the first two decades of the present century. At the time of the outbreak of the Second World War in 1939, India had 11 engineering colleges with an annual intake of 200 students while most of the apprentice mechanic training programmes were undertaken by the Indian Railways, and the ordinance factory, the Port Authorities and the Public Works Departments of the States.

Planning and Development: Fresh positive step was taken by establishment of AICTE in 1946 and a scientific manpower committee in 1947. AICTE approved a committee under the chairmanship of N R Sirkar to advise the Government of India on the facilities and schemes for development of technical education. The Sirkar Committee recommended establishment of four higher technological institutes with a total capacity of 2000 UG and 1000 PG students. IIT (KGP) was established in 1951, followed by Bombay, Kanpur and Madras in 1957, 1959 and 1960 respectively. High priority for technical education were given during the First and Second Five Year Plan and College of Engineering & Technology was established in New Delhi which was later designated as IIT. Fifteen Regional Engineering Colleges were proposed of which 14 were established between 1959 - 1964 and the 15th in 1977.

With the policy to encourage establishment of engineering colleges and polytechnics with financial support from private agencies, nine engineering colleges and 23 polytechnics were established during the Second Plan. In 1948 there were 38 engineering colleges and 53 polytechnics with an admission capacity of 2 940 and 3 670 respectively. By the end of the 1st Plan (1951-56) the intake capacity doubled in degree colleges and tripled in diploma colleges. By the end of the Second Plan (1960-61) the number of degree colleges increased to 102 and polytechnics to 195, with admission capacity of 13820 and 25 800 respectively. The outturn of graduates and dJploma holders increased from 1 270 (1947) to 5 700 in 1960-61 for degree and 1 440 in 1947 to 7 970 in 1960-61 for diploma and by the end of 1963-64 the number of degree colleges increased to 120 and poly technics to 269 increasing the admission capacity to 20 780 and 40 000 at the two levels.

The Engineering Personnel Committee appointed by the Planning Commission in 1955, estimated the number of 26 500 students in degree and 50 500 in diploma holders would be needed in 1960-61. This target was revised twice during the Second Plan and new targets for admission for degree were set for 19 500 and 27 000 was reached. In the Third Plan no serious shortage was anticipated but for the Fourth Plan, the admission facilities were proposed to be revised to 20 000 and 40 000 by the end of 1965-66. In fact, the facilities created in 1963-64 was considered adequate to meet the target.

Due to industrial recession, the intake of engineering colleges and polytechnics was proposed to be reduced by 30% in 1968 but in 1974, the AICTE suggested that the earlier cut back in admission may be restored. By 1977-78, the admission figures were brought back to 25 000 and 50 000 on an All India basis.

During subsequent years demand for admission, particularly at the degree colleges, increased considerably because of many factors, one of them being the large increase in the number of the eligble high school leavers preparing for a career in engineering. The popular demand of students whose employment was not restricted to the jurisdiction of the state or even the whole country induced some state governments and private enterprises to expand existing institutions or set up new institutions with or without approval of the AICTE or the Government of India. In 1980-81 the admission capacity increased to 38 200 for degree and 60 000 for diploma in 174 degree colleges and 354 polytechnics.

This capacity has further increased and at present, there are more than 300 engineering colleges and 500 polytechnics, some of which have yet to receive recognition with an approximate admission capacity of about 40000 for degree and 75 000 for diploma courses. In addition, the Institution of Engineers (India) through its examination system produced another 3500 qualified engineers by passing the section Bexamination.

Engineering education faces more challenges than any other discipline. Educational institutions of all categories in engineering, technical and management and architecture under the perview of AICTE, which separately regulates controls and governs almost all activities with near absolute power with which the body has recently been vested by an act of Parliament.

The weak link between technical education and industry is seen to be getting weaker and weaker everyday with rather limited involvement of either the education authorities or the professional institutions like lEI.

Challenges for Technical Education

Uncontrolled Growth

Apart from the problem of numbers and weak link between technical education and industry, the rapid growth of educational institutions due to upsurge of eligible candidates at +2 level, has affected the quality and accountability of the products turned out of these institutions. Moreover, a number of engineering colleges and polytechnics have been set up recently by private enterprises with inadequate infrastructural facilities more or less on commercial basis without any approval of the appropriate authority of the State.

Industrial Training

Industrial training and exposure to 'the world of work' which is considered essential for complete education "of engineers and technicians is often not available for a large section of the products of engineering colleges and polytechnics due to limitation of availability of training places in industry. The Regional Boards of Practical Training, which were established for the purpose, can hardly cover 25% of the demand. They are cornuelled to accept jobs without training and in many situations not compatible with their education.

Quality and Equality

The problem of quality with equality is becoming a major issue in the technological education scene. The push for equality is often not restricted to access alone but also equal achievements which seriously affect the normal academic life of students and faculty and creates serious administrative problems.

Inadequate Resources

Increased cost of technical education due to higher pay and allowances of faculty and supporting staff and increased cost of maintenance of the infrastructural facilities and cost of consumables has seriously affected the standard of instruction and campus discipline which are essential for maintaining the quality of technical manpower produced. Poor and inadequate hostel accommodation, with inadequate facilities for sports, games and other extracurricular activities are no exceptions to most of such institutions. Government funding has fallen far short of the basic requirement while there is no financial support from end-users, viz, industry.

Specialization and Diversification

Rapid growth of technology and necessity for specialization and diversification even at the first degree level and rapid obsolescence of the conventional courses at degree and diploma levels have imposed additional strain on the technical education system.

Technical and Management Education

Lack of coordination between technical and management education and the manpower needs in different sectors of the society has resulted in utter frustration amongst the students and the faculty which has seriously affected the quality of manpower produced at such high cost which our economy can hardly sustain if it does not pay back in the form of service.

Professional Societies

Professional societies in engineering and technology have been playing a passive role in the policy making bodies for control of quality and quantity of professional manpower development. They have not applied themselves for bringing the professionals on a common platform and raise their voice regarding the role of professional vis-a-vis the industrial sector who use them.

Professional Accountability

Professional engineers and technologists should be held accountable, whenever an engineering design or construction or project is involved in a major accident or environmental pollution leading to disaster. Such public accountability can come or be imposed only when the practise of the profession is controlled by a legislation for a newly administered register of professional engineers as a measure of competence to practice specific engineering tasks. This will also act as a guide to employers and public regarding their professional capabilities and reliability and would thus raise the status and responsibilities of those so licensed. Professional institutions like The Institution of Engineers (India), which is the largest recognized professional body of engineers and technologists in the country, should be holding powers to grant such professional licences and appropriately designate them as in other advanced countries.

It should be realized that engineering professionals in India have been left to grow and function as self-oriented individuals without any obligation to the profession, the society or to the country. We need to voice as a professional community that would carry authority at the highest levels on matters relating to practise of engineering and technology, particularly on issues of manpower planning and development planning for techno-economic development and environmental control leading to welfare of the country and the world.

Value Education

It has been recognized by the leaders of the country that there is an urgent need for value education in our culturally plural society. 'Moral' and 'Spiritual' values which are the the backbone of any education system has been left out of our curricula for too long resulting in rapid erosion of senses of values at all levels in the society. The NPE (1986) has identified this lacuna and has recommended that emphasis be given on this aspect of education which should help eliminate obscurantism, religious fanaticism, violence, superstition and fatalism.

Environmental Education and Awareness

Although most of the people at the level of policy making recognize that there is urgent need for environmental education at all levels from elementary to post-graduate studies including research but only a few had clear idea as to how or what should be done.

Dr T N Khoshoo, in his presidental address at the 73rd session of the Indian Science Congress Association, New Delhi, said, 'Awareness of real-life situation, conservation and sustainable development are the concepts that should be inculcated at all levels of education, matching with primary, secondary and higher education, specially in science and technology curricula. 'Economics' and 'Ecology' which have been derived from the common root, should be deeply integrated in our planning and execution process for a sustainable development on a long term basis.' We have a long way to go to achieve this basic awareness.

National Policy on Education (1986)

The Government of India, in their National Education Policy (1986), have identified some of these areas which need to be tackled with high priority. A number of programmes and projects have been taken up for modernization and removal of obsolescence in technical education with financial support from the centre.

To ensure coordinated development in accordance with approved standards, the All India Council of Technical Education (AICTE) which was set up in 1945 as an advisory body to the central and state governments has been given the status of a statutary body by an Act of Parliament (1987). The powers and functions of the Council have been extensive to perform and ensure integrated development of technical education and maintenance of standards including allocation and disbursement of funds. It is hoped that prompt and effective steps would be taken before the issue gets out of control. '

Making Prophesies for Future

We hardly know ‘what the environment of tomorrow’s’ will be like but we already know what its heredity will be like. It may be generally expected that during the next decade the enrollment in higher education. Particularly in science and technical institutions will continue to increase inspite of the influence of political, economic and social changes. The three E's — econorny, energy and environment-will probably be identified as the ruling concerns of public and private lives and will be handled appropriately with high priority but the most important issue will be the fourth E. viz, ethics which will be able to evolve a system of life that will almost certainly ensure better growth of society in more qualitative and less quantitative terms . Education of the right type will even be more essential to developing countries in the years 2000 AD and beyond than it is today.

In the words of Pluto, 'When the wheel of education is once set in motion, the speed is always increasing .....’. ‘The question is 'what do we do now?’ ‘wait or try to steer it in the right direction to save us from catastrophy.’ ‘The year 2000 will arrive at its own pace. The effort to look at it in advance involves, in part, curiosity and in part a hope to change its contour, or at last adapt, in advance, to its anticipated constraints.’ so said, Dr Clark Kerr, Chairman. Carnegie Commission on Higher Education, USA.

We, no doubt, find ourselves in a hall of mirror with distorted reflections all around us. We should be prepared to reject, at least in part, each and every one of them and evolve a course of action that would lead us to a better world in the next century.

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Challenges in Science and Technology

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It is generally assumed that science and technology are essential ingredients of national development. Without enough science and technology, no country today can be counted as a modern nation or as a bona fide member of a progressive world community. Unfortunately, however, all countries do not have the same capabiiities and opportunities. We in India are if, a unique position wherein we have developed a reasonable infrastructure in S & T although we are economically poor. We have a tremendous challenge in the years to come because of the increasing global competitiveness. Globalization has become a feature of all efforts today not only in economic and industrial development, but also in scientific research and technological innovation. Furthermore, the geopolitical and economic scenarios in the world have undergone and are still undergoing unprecedented changes. In view of this situation, it is worthwhile to ponder as to what one has to do in a large developing country like India to remain competitive. Two of the key elements of being successful and competitive happen to be excellence and accountability. In trying to be competitive, we have to compete with the best and, therefore, we have to be outstanding in our performance. Whether it be basic scientific research or technological innovation, it is only through excellence in prformance that we will be accountable to the society which supports us.

BASIC SCIENTIFIC RESEARCH

In the last few years, we have been carrying out scientific work in some of the frontier areas in science. However, it is becoming extremely difficult to carry out research at the cuttinq edge because of the tremendous demands being made by the increasing quality and changing nature of world science. The kind of experiments to be carried out in physical and biological sciences as well as in engineering requires extraordinary facilities and support. Mere ideas alone do not suffice. The experimental facilities and infrastructure required to test good ideas are difficult to obtain. In spite of such limitations. A few scientists continue to make efforts in this country to work on certain chosen frontier topics. In many instances, one has to develop the infrastructure and build the necessary instruments for experimental work. The problem is that even as we Keep improving, the competition as well as the gap between us and the advanced countries keep increasing. Because of this continuous increase in the 'gap', it js trying on those who want to compete in fundamental sciences from India and do sornethinq worthwhile. Yet, unless we are competitive, there is no hope because for science, the frame of reference is international and there is absolutely no sympathy or consideration given to those coming from poorer countries by those in advanced countries. It is a straightforward competition, just as in the field of sports, except that we do not 'see' our competitors when we are performing. Planners and providers in the country do not seem to be fully aware of the magnitude of the problem for, otherwise, they would have supported science differently. Let us remember that the best of our laboratories in most areas stand poor comparison to those in advanced countries.

Let me also point out that unless we win in this kind of competition in fundamental sciences, even marginally, we cannot justify funding of fundamental sciences. As I mentioned, funding for fundamental sciences in India is not very high, but what we have received deserves better returns. While whatever funding we have received for fundamental research is to be accounted for by performing high quality work as evidenced from papers in the best journals, we have to, at the same time, keep improving the facilities and infrastructure to be able ItO carry out competitive research of current relevance. The number of good papers coming from India in the best journals in most fields is not very high. At least in my field, there is not even 100 papers from the entire country in the leading journals of the world. This should be compared to the performance of a good department in a good university in the US which publishes about 100 papers during a year. We really have a limited number of outstanding persons in most areas.

All countries have not been successful in fundamental sciences even in the developed world. For example, it is only recently that there is increasing realization in Japan that fundamental research has to be supported in a very big way and in the last two years Japan has increased support for fundamental sciences from the government. In the last year they have doubled the government support for fundamental research which they feel is necessary during recession (a situation that is opposite to what prevails in India). Japan, although a global leader in technology and industry, has not done as well in terms of Nobel Prizes and other types of international recognition in fundamental research. America, which continues to be the leader in fundamental research, appears to be doing not as well in technology and industry. Britain, which was a cradle of ideas in science at one time, does not appear to be doing too well either in science or in technology. I am giving these comparisons only to show the kind of world we are in today.

There is some fear that even the little support that we are getting in India for fundamental research during the last few decades may gradually decrease. The government should ensure that this feeling is proved wrong and continue to protect what little gains we have made in the areas of fundamental sciences. Our educational and R&D organizations cannot fund for themselves overnight. Our situation seems to be somewhat similar to that in Russia and in some of the east European countrie- where at one time their academies ruled supreme but today their scientific institutions are suffering badly because of the feeling in their governments that science is not that important.

TECHNOLOGY INNOVATION

When it comes to technology innovation, global competition is much more severe. The Government is investing in some of the R & D organizations since their inception. While some of the mission-oriented agencies have done well omnibus agencies such as the CSIR have had difficulties. Part of the difficulty stems from defects inherent to the structure of these orqanization and the absence of appropriate linkages. Hopefully, they will forge new relations with the industries and other national and international R & D bodies in the near future and produce significant results. We cannot blame R & D organizations alone. Our industries have not found it really necessary to support research and development. If 'not, why is it that our Government is supporting almost all R & D ? If industries were interested, they would have done so by now. Profit motive is the one thing that guides industries all over. Obviously, they have not found it necessary to go for R & D to do well. Ho Never, the situation is fast changing and if our industry has to be competitive, they will have to support R & D so that they can do something innovative that can be sold. Let us not forget that in the area of technology also, India will have to compete with the most advanced countries if it has to export goods. Even for the domestic market, it has to produce better goods since the domestic market is now open to international competition. It is my definitive view that no new or novel technologies will be provided by foreign countries. They have to emanate from national effort.

Globalization of R & D is also going to affect technology innovation. It may be useful for us to become part of global R&D efforts in some way in addition to making our own national efforts. Competitiveness and excellence will be crucial to enter the global R & 0 scenario.

In the area of technology, the only way of showing excellence in performance is by competitive innovation and at the same time producing technologies that can be directly used in industries for export and domestic markets. Another aspect is the R & D work related to quality improvement. Since quality improvement by and large is required in almost all asnects of Indian life and industry, this requires serious consideration. Here we can probably do enough to show results to be accountable. Since India is a large country with a large population, there are several demands which would not only involve international competition but would also require solutions to local, regional and national problems of importance.

INDUSTRIAL DEVELOPMENT

India will have to struggle very hard to become a member of the modern industrial world. There is every possibility that multi-nationals and large industries will take a lion's share of heavy engineering and other industries. We have therefore to be careful in development the mosaic of our national industrial scenario. We must ensure that our investments in industrial sector are in those areas which are crucial to development. Let us not forget that we have not done well even in the crucial fertilizer sector. We are still importing urea! There are success stories such as in the medium and small-scale chemical sector where we have increased our exports to around Rs 20 000 million per year based on Indian R & D and innovative technologies. But we have to do much more. We do not have equivalent success stories in heavy engineering. We always record our successes in space or some other agencies. I do not think that this is relevant when it comes to industrial development to trigger national economy. We have to take those steps in technological innovation and industrial development that suit our temperament and our genius that wduld enable us to become truly competitive in certain sectors. For example, we are good in software development. Yet we do not have a sufficiently organized software development programme. We hardly have 0.1 % of the world market in this area. Because of our easy access to labour, we should have taken world leadership in industries which are labour-intensive. For example, making inexpensive radios or watches should have been our real forte. But we have not become production centres of such commodities which -can be sold worldwide unlike China which dominates the world market. In spite of our large domestic market, we have to sell goods in large quantities outside. Without such resources from export, we will have difficulty in maintaining ourselves. While we may not get a place in heavy engineering or in high-tech areas, we probably have a place in the production of inexpensive consumer goods. I also believe that the Indian genius is highly suited to knowledge-based industries, such as sensors, which can be set up in small rooms without heavy investments. Clearly in all such efforts, excellence has to be the hallmark in order to be able to be competitive. A careful prioritization of our national efforts in this direction is called for.

ACTION POINTS

The following are some of the important S&T efforts required to promote excellence and accountability.

- Basic scient.tic research in chosen areas has to be adequately supported in order to be competitive Internationally.
- There should be sufficient investment in S&T related sectors which are directly related to the prossing problems of mankind such as agriculture, food, health), etc.
- S & T related to crucial sectors such as communication, energy, biotechnology, advanced materials and informatics has to be supported since these areas will determine the course of the next century.
- We need to invest heavily in certain specific areas where we have certain unique advantages due to the available natural resources, or other special features. Solar energy beneficiation (photovoltaics) would be one such area.
- R&D required for technology development, upgradation or modification in export-oriented industries (eg, knowledgs-based industries) has to be supported. Industry has to take a major responsibility in this aspect,
- We have to carefully decide what our role would be in global R&D. Can we become partners in global endeavours?
- We have to ensure that science and technology find an adequate role in upgrading our performance in socio-economic sectors (such as coal, building construction, railways, etc) and in improvement of quality in industrial production and other sectors.
- Funding of higher educational institutions and national laboratories should be sufficient to improve their crumbling infrastructure in order for them to be able to carry out high quality R&D. Here again, industry as well as other private initiatives have a major role.

All this can be done only with the cooperation of our scientists and engineers. We have a small number of talented people and it is necessary that they are fully supported and encouraged. A positive attitude towaras S & T efforts and towards scientists and engineers by politicians and administrators will yield results far in excess of expectations based on investments and will motivate scientists and engineers to work beyond the call of duty.

CONCLUDING REMARKS

The chanqtnq geopolitical and economic world scenarios have thrown great challenges. These can be met only by an orchestrated programme of action invloving selective investments on R&D leading to technological innovation as well as on chose" areas of fundamental sciences and engineering. In this season of competition, the Government has a crucial role to play. Since the Government has been entirely responsible for S&T in the country till now, it has to ensure a safe transition to a new era where industry becomes a real partner in promoting S&T. Benign indifference at this staqs may wipe out the advantages of a reasonable S&T infrastructure that we have built up over the years.

Let me hope, in spite of all that I have said, that by the turn of the century, each of us will have found the profit motive that propels us to excel – and that S&T, industry as well as national economy will have become independent of national politics.

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The Changing Face of Science and Technology

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A few months ago, I attended a college function as Chief Guest. Sharing the dias with me was a well-known poet. As is customary, we were expected to address the students and the poet got the mike first. As I sat there expecting to hear a talk on some of the finer things in life such as prose, poetry and culture, the speaker went on into a scathing attack on Science and Technology for the next fifteen minutes or so, all the time apologizing to me for being blunt. His main line of argument was that modern science and technology is responsible for most of the present-day ills like the weapons of mass destruction, environmental pollution, indiscriminate mechanization leading to mass unemployment, etc. He concluded that if our forefathers could live comfortably and peacefully without modern science and technology, we could also do so. We should therefore deliberately slow down our efforts on Science and Technology, but concentrate instead on social issues. I have also come across similar views being expressed in various fora where again one seems to advocate increased investments on social issues rather than on Science and Technology. In all these cases, my first reaction is always one of anger. Here are individuals who have derived several benefits of modern technology-comforts, communication, transport, health, etc. They choose to ignore all these and instead blame S & T for its misuse. Sometimes, I also get amused. Imagine a scenario where these individuals are suddenly deprived of all scientific and technological support. Will they be better off than what they are today? Even the thought is ridiculous. What prompts well informed educated, individuals to argue that modem S & T is responsible for its ills which, in their opinion, overweigh the benefits? Why such doubts are being expressed now and not earlier? Knives have been used both in war and in peace. Fire has been used for cooking as well as for arson. Nobody blamed science for discovering fire. Why blame science now for the ills arising out of its misuse? This is the question I will like to address to this talk.

The last two centuries, the 19th and the 20th, are often referred to as Science and Technology Age. It should however be remembered that Science and Technology have always been intimately connected to human development for ages. For example, the early stages of development of mankind are referred as the stone age, the iron age, etc. In modern terminology, material technology was the yardstick of human development. The discovery of the wheel,fire and agriculture is all milestones in the scientific development of ancient civilizations. What then differentiates the present-day science and technology from the science and technology of the yesteryears? The definition of science as the search for new knowledge and technology as new application of the acquired knowledge is still the same. What has changed?

One change which we have all seen even during our lifetimes is the increasing pace of scientific research and its impact on our day-to-day lifestyles-what I will like to call as the velocity of research. Orle hundred years ago, new discoveries were few and far between. Their impacts on human lifestyle were slow to come even when they are profound and far-reaching. Compare it with the present-day scenario. A few decades before it was the atomic age. Today, it is the information age. Tomorrow what it will be, I do not even venture to guess.

A second change which we are all seeing is the increasing role of sophisticated instrumentation with unimaginable capabilities. Not only these have broadened the scope of research, but they have also contributed to the increasing pace of research, mentioned above. It is said that Sir C V Raman carried out his Nobel Prize-winning investigations with instruments worth a few hundred rupees. I am not sure whether today we can carry out competitive research without competitive instruments.

There is also a boot-strapping effect between scientific developments and lnstrument development. New discoveries lead to the development of new instruments. New instruments lead to new discoveries. This results in addition to increased investments in the equipment but also lead to a fast obsolescence of the equipment.

Recent progress in transport and communication have also contributed to this increasing pace of research. There has also been a qualitative change in the way research is being done during the last few decades or so. In the early days, research used to be the pursuit of choice of a few motivated people without much of material gains. During the early part of this century, this changed. The now famous Manhattan Project demonstrated what can be achieved by mobilizing a team of scientists and technologists, setting them a goal, providing them the necessary facilities and rewarding them appropriately. The model has been adopted by industries and now sponsored research has become the order of the day. It has also been realized that scientific and. Technical knowledge is power and could easily be turned into a weapon. Intellectual property, like any other property, is to be acquired, protected and managed (purchased and sold). Present discussion on IPR and other related issues are manifestations of the above realization.

Has this explosive growth in Science and Technology benefited the society? I do not think that anyone will dispute that it has, in spite of some misuses of the new knowledge-in fact, use and misuse are in t,le hands of the user and one cannot put the blame on Science and Technology for the ills of misuse. Why then is the new scepticism mentioned earlier? For this, one has to look at some of the negative developments of present-day research. At the top of this list is the increasing cost of research. The need for more and more sophisticated equipment has understandably made research expensive. It is not important who pays for the same, Government or industry; Ultimately, the burden for increasing scientific activities fell on the public, indirectly if not directly. There is, therefore, an increasing awareness among the population about their right to know how this investments on scientific research will benefit them. While on the face of it this is a welcome development, this also puts an undue importance on short-term, visible benefits, often at the cost of long-term implications. This has made science vulnerable to external non-academic manipulations.

More important than the increasing cost of research is the inherent lack of equity in societal benefits of technology, leading to national, regional and social inequalities. It is known that while science is universal, less than 10% of the world population reap the full benefits of the modern technology. Worse still, they consume maximum resources, contribute to environment deterioration and reduce the majority to a state of irrelevance. This lack of equity has been the root cause of many a conflict, intemational or otherwise. Technology has become a weapon, a weapon of the rich against the poor, of the literate against the illiterate, of the developed against the developing or underdeveloped. We face the danger of a new scientific discovery which can alleviate human suffering or improve the quality of life of a vast majority becoming the protected property of an individual, a company or a nation. There is a genuine fear among the population about the direction in which modern Science and Technology is leading us. The cynicism expressed in the two examples I quoted in the beginning has its roots in this fear.

How do we the scientists, the technologists, everyone who is concerned about the future of humanity respond to this? How dowe ensure equity? How do we eliminate exploitation by a few? How do we convert the knowledge weapon into an instrument of growth and prosperity for all? First and foremost, for any group — national, regional or social — there is no escape from a strong science and technology base. The base should be adequate to develop location specific home Grown technologies and ensure full exploitation of local resources and adopt and absorb technologies developed elsewhere. This will in turn ensure adequate bargaining power and prevention of exploitation by others. Deliberate efforts should also be made to reach the benefits of technology to the poorest of the poor by increasing their earning capacity and in general make them self-reliant to stand on their own legs. It is also necessary to create awareness among the population so that environmental and social costs of any new technology is appreciated by one and all. These are challenges to all of us and it is also time to face these challenges because it may be too late tomorrow.

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Technology Transfer Processes — A Study

Shri V K Saraswat

Project Director, PRITHVI

Technology has become an important element of our society. Its importance has been growing in the past few centuries, mainly after the Industrial Revolution, and has now reached a stage where the quality of life of a society, its well-being and security are determined by it. While the Industrial Revolution of the last century replaced muscle power by mechanical power and multiplied the output of individual and groups, the new technological developments are promising to take this change a step further, enriching the way they live and work. Thus technology is turning out to be an engine for growth, structural transformation and modernisation of our society.

Technological innovations are often the consequences of articulated demands of the market and are sensitive to many factors, some technological, many economic and even social. The assessing and choosing of technologies is an important factor in linking it with the production of goods and services. Another major component is the way technology is transferred from laboratories and assimilated in industries. The latter embodies in it the diffusion of technology and the potential to teach the practitioner to be innovative. This process of acquiring skills, the so-called 'learning by doing', has turned out to be a vital factor in absorbing innovations for manufacture.

Many developed countries have become adept in transferring technology among their institutions. There are also examples where technology transfer has become a problem with poor diffusion and still poorer assimilation: One transfer does not blossom into many innovations, but end as a solitary product or service, vulnerable to competition, and easily overtaken by newer innovations. Why is this so, even when the transfer between laboratories and industries is within the country?

Issues on Technology Transfer

There are two major issues that have to be considered while analysing the technology transfer problems. The first concerns "the problem of technology choices, identification, assessment and mode of acquisition and the second of providing a seamless interface between the developer and the industry".

Choosing Technologies: Core Technology & Critical Technology

Technologies reach many fields of human endeavour from human welfare to defense. Some technologies are rich and robust to contribute to many sectors and some may be limited and sector specific. We define core technologies as those whose impact on growth is significant in may sectors. The versatility of such technologies makes them amenable for better absorption and subsequent growth in many different sectors of the country. Information Technology with its spectrum of ever-increasing applications - is indeed a Core Technology. The concept of Core Technology has a wide applicability, from a company level to a country level and is determined by the sectors that are relevant to the company of a country. Wider applicability and greater relevance make the technology diffusion mechanisms more efficient. As technology awareness develops a larger human power participation would lead to a better assimilation and innovations.

Critical Technologies are either available in a limited way or non-available to a firm or country - as a consequence of policies of other governments, protectionism by firms abroad, or because of their non-existence - and which are important to the firm to achieve its economic goals and the country to achieve its social, economic and security objectives. Thus a technology becomes critical only in the eyes of the receiver. For instance, the rocket motor for satellite launching vehicles is a critical technology for India as also technologies for altering the unfavourable alumina/ silica of Indian iron ore ratio and coke with its high ash content.

Core Technology and Critical Technology have precise meanings but they are interchangeable in some cases. Some of the critical technologies can indeed be core and vice-versa.

Technology Assessment

It is necessary that the country (industry) has the tools available for assessing the technology even during the initial stage of development to ensure that the technology meets, or has the potential to meet, its objectives. If the interest is in looking at the impact of technology at social level, then the assessment has to be viewed at an aggregate level. On the other hand, if the decision problem is at a level. say, in choosing technologies for telecommunication systems that is internationally competitive, then the problem gets focused into a single functional area.

The basic functions that societal technology can provide are in communications, transportation, public health, habitat, education, recreation etc. For each function, the basic characteristics that determine themaximum quality of serving the function, given the technology. We specify the following three characteristics as adequate to describe a technological innovation (i) performance, (ii) robustness, and (iii) manufacturability.

Mode of Acquisition of Technology: 'Make' or 'Buy' Options

Options for acquiring the necessary technology for a new product or for providing a new service. The first is to acquire the total technology package with the know-how from outside, or to develop it ab initio at its own or other R & D Centres. Issues on technology transfer are different for these two options because of the different input needs. For Developing Countries, the 'make' option is usually an exception rather than a rule. The 'make' option becomes the only route when needed technologies are not available because they do not exist or because of competitive reasons. However, the 'make' is really not an option for many - only the developed countries, large firms and global corporations are able to provide the necessary infrastructure, afford the costs and risks inherent to development.

The 'Buy' Option

The 'buy' option is seen as an easier route to introduce a new product in a short investments or risks. Technologies are bought either as embodied components such as machinery, equipment and the necessary know-how-the hardware-or as disembodied that include all the software-the knowledge base for the innovation — that goes into the development of technology. Many buyers of technology, specially from the developing countries, consider the embodied part as adequate, and this may indeed be the case for low level technologies. But sophisticated technologies demand more than mere machines for an efficient technology transfer, the technology for a new computer, for instance, will have to include various details of its compatible software in addition to a description of its embedded microprocessors.

Cost Factor

The cost factor includes not only the cost of acquisition but also of assimilation. In developed countries, depending on technologies, the assimilation costs are higher than for acquisition, while in developing countries for the same technology, only the acquisition costs matter. Japan spends about eight times the cost of acquisition in assimilation and, for the equivalent technologies, the Indian expenditure is a mere fraction of the acquisition costs. Thus, unraveling the technology, assimilating its features for manufacture and learning from the knowledge spill-over are all lost when assimilation is ignored. Lack of assimilation makes imported technologies age rapidly with time and become uncompetitive, both nationally and globally. Incremental innovations are not then possible and when newer versions re-needed, they are acquired again. This has been the case in 99% of Technology Transfer cases in our country.

For assimilating disembodied technologies, the receiving firm must possess critical mass of knowledge works (scientists, engineers and technologists) for unraveling the technology, learn its features and build further on it. To ensure this, many East Asian countries purchase technologies through research institutes, universities or consortia created specially for technology dissemination. They also send a large number of engineers and other technical personnel to work at the seller laboratories and factories.

The 'Make' Option

The 'make option is determined by the availability of resources both infrastructural and human-and by a commitment to develop the technology in-house, or within the country. Technology development, today, is viewed more as a concurrent process where various divisions of industry, laboratories and design centres interact with each other than as a linear research-tomarketing model. The concurrent engineering model is an interactive one with well-located feedback systems ensuring the evolution of 'design to manufacture'. This practice is refreshingly different from the earlier model which assumed the 'technology push' as the main driving force for innovation ignoring at least during the development stage, the demands of the manufacturing and marketing personnel. The new trend however is to integrate all laboratories with industries either by co-location or by forming integrated groups to address problems of technology development. The ownership of laboratories may also pose problems.

Interface Structures

There are five ways of forming laboratory-industry linkages with the laboratory playing the role of (i) an investor, (ii)a retainer, (iii) a promoter, (iv) a leased unit and forming, (v) a consortium. Among these, the laboratory takes the lead only when it becomes the primary investor or a promoter and 'in others, it works as a participant or a collaborator to the industry. When technology is bought either from outside or developed by the industry, the laboratory can help to choose the appropriate technology and service it, as and when required.

Management of Technology Transfer Process

The management of technology transfer is basically the management of three types of cultures, symbolised by the research scientist or the inventor, the industrialists and the designer / developer. The management calls for establishing couplings and bringing these groups together. The three groups have different modes of thinking attitudes, motivations and interests. For example, while the research scientist lives in the realm of ideas and is more concerned with the development of new processes by exploiting the laws of nature, the industrialist lives in a society where profits and generation of wealth are prime motives. The dream of the designer is realised only when developer or designer comes in between the two. Designer has to work in both the worlds and hence has to serve as a bridge between the two. The task of a technology transfer manager is to bring all these people together. Four key variables emerge as critical in this process of bringing these people together.

◇ Communication
◇ Motivation
◇ Distance
◇ Technology equivocality

Technology Transfer Manager should influence, direct and monitor each of these variables. Also there is an important relationship among these variables which can be ranked from low to high.

Communication

Communication between the technology transmitter and receptor involves both passive and active links. Passive links are research reports, articles, computer tapes and video tapes of information.

• It is low cost and can cover widely dispersed audience at the same time
• Transmitter is unaware of whether and how the receptor receives and utilises the transferred technology

Active links are direct, person-to-person interaction. They may range from teleconference to ad hoc teams and on-site demonstrations. These links give inter-personal communication in terms of fast, focused feedback. It is costly. However, one important aspect is that in this case the receptor should have the desire and time to communicate across organisational boundaries. The weaker the communication link, the less likely is the chance that the technology will be successfully transferred.

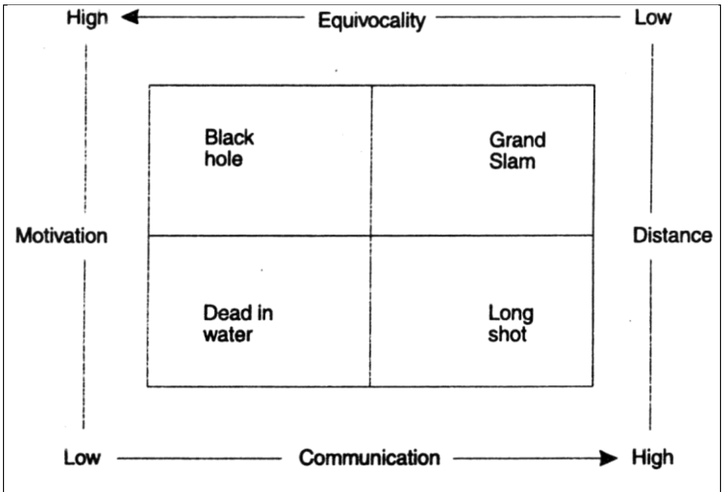
The second variable distance involves both geographical and cultural proximity or separation. Geographical distance between the researcher and developer who is the donor and the industry / entrepreneur who is the acceptor should be minimised to accelerate the Technology Transfer Process. The geographical distances can be bridged by keeping the transmitter and receptors under one roof. However, cultural differences as described above loom as more important dimension of distance. The higher the cultural difference, the more difficult is the transfer process.

Equivocality

This refers to the level of correctness of the technology to the transferor. Low equivocality in technology is fairly easy to understand. It conveys the same meaning to every body. Highly equivocal technology will be harder to transfer. It is more difficult to demonstrate and ambiguous in its potential application.

Motivation

It involves incentives for and recognition of technology transfer. Motivation varies by importance of technology transfer in the culture of the organisation, the criteria by which the individual is evaluated and the rewards for those who are involved in Technology Transfer. Both donor and acceptor generally ask 'What is in it for me'. The greater the variety and degree of incentives, rewards and recognition, the higher will be the motivation. The technology transfer grid given below describes four organisational situations affecting Technology Transfer. The relative importance of these variables should be understood by TOT.



Technology transfer grid

Technology Transfer in Concurrent Engineering Environment

The requirement of reducing the time from concept to production requires that the work which is normally conducted in series be carried out in parallel. This concept is referred to as concurrent engineering where technology development, technology transfer, production and marketing all take place together at the same time perhaps throughout the life cycle of the project. Generally, it is claimed that this approach reduces the time schedule for a project by 40%. Various phases of the project like conceptual studies, feasibility studies, preliminary planning, detailed planning, execution, technology transfer, production and marketing all run in parallel.

Imagine the problems of technology transfer in an environment where

- technology uncertainty exists
- risk is very high
- specifications and designs keep changing
- development plans are frequently changing varied
- documentation for technology transfer is half cooked

In a conventional sense this is an invitation for disaster in the eyes of an entrepreneur. But for a Project Manager, it is a challenge which should be met using the technological innovations and modern methods of project management which call for laying down general project guidelines, preparing checklists and carrying out periodic reviews at different points of the project.

The conventional Project Manager becomes a manager capable of coping with

a) living project plan document subject to change
b) multiple critical paths
c) ever-increasing risk
d) ever-changing specifications
e) multi-disciplinary knowledge of business

Technology development and transfer in an environment of concurrent engineering needs a sound management structure which empowers the project manager to cope with all the situation of risk. Generally, a Project Manager becomes a risk manager. The management structure should reduce the gap between the researcher, designer Ideveloper and the industrialists.

This experiment has been successfully tried out in the case of Integrated Guided Missiles Programme wherein development and productionisation ran concurrently. Commencement of production of Prithvi immediately after the acceptance of the product by User is a living example of TOT in concurrent engineering mode. The salient features of this approach are given in succeeding paragraphs.

Prithvi Approach to Technology Transfer

The Technology Transfer process in case of Prithvi Weapon System development was supported by a three-level management structure and matrix organisation with the project team and the technology development centres. The production agencies and the user agencies were made part of this three-tier management system for better communication, decision-making and commitment.

This helped in bridging the cultural gaps and appreciation of each others perspective. In the concurrent engineering mode the following approach was implemented.

a) Identification of Prime Production agency at the feasibility study stage of the project.

b) Identification of other production agencies at the Preliminary Design Review Stage for the production of the subsystems. Involvement of prime production agency during the selection process.

c) Programme Management invited the User service namely Army to participate in development tests, evaluation of sub-systems and project reviews.

d) An excellent design review system was introduced wherein designs were reviewed by a team of experts from national laboratories, academic institutions and production agencies.

e) All the static test results and flight test results were reviewed by expert committee.

f) All the equipment and machinery required for production of sub-systems were procured, installed and commissioned by the time the first flight test was completed.

g) Production agencies were given the orders to produce sub-systems for the flight test programme.

h) Extensive documentation in the form of PDR Document, Baseline Design Documents and Quality Assurance Plans were given to production agencies for understanding the technology.

i) Active participation of engineers from production agencies, inspection agencies and the Users in the development activities, flight testing, post-flight analysis, failure analysis and review of the project activities helped in technology transfer considerably Training of Engineers and technicians in the fabrication, assembly and testing of the sub-systems was organised.

j) Project Team participated in the identification of machinery, test equipment and design of test methodologies for the production agencies. Help was provided in the commissioning of the equipment. Designers participated in the production of first batch of sub-systems.

k) Risk due to redundancy of sub-systems, materials and equipment resulting from design and user driven chains was managed through

- funding of development order by project
- sub-system configuration control in real time
- quick decision-making for introducing the changes

1) Participation of designers, project-team members in the production readiness reviews and technology transfer reviews

m) Component deviations, rejections, functional failures and system failures were reviewed by designers and project team members periodically, causes identified and suggestions made for improvement.

This approach reduced more than 40% times in technology transfer and assimilation

Conclusion

Technology Transfer is a complex process. It begins with the identification of technology. The choice of the core and critical technologies should be made. In a developing country like ours, it is essential to have appropriate tools to select the right technology. Import of technology should be done by a consortium of laboratories and industries to enable assimilation of the disembodied components of technology and technology spill over. Industry must be the primary agency in technology development in partnership with research laboratories. The consortium approach enables faster technology transfer. There are cases where an interface organisation like NRDC or any competent consultancy agency can act as a bridge between development agency and industry. In defence sector, where research, technology development and production operate seemingly without discord, the premium on performance and reliability of the products is so high that the attention is paid more to product than to process technologies. This approach leads to high cost of production. The effort should be to develop and transfer the process technology in parallel. With the onset of concurrent engineering in all product development projects, the technology transfer will be strengthened and concurrent through the radically different management structure and the associated enriching mechanisms.

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Science, Religion and Vedanta

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Abstract

Both science and religion enquire into the problems of human existence and find their solutions. The Vedanta had identified some characteristics of both. Science deals with matters which come within human perception and the results of science are ever changing. Religion deals with matters which are supersensuous and absolute. The Vedanta accepts the role of rational efforts in the realisation of the aims of religion but asserts that it is the religion which alone can integrate science to life and give it a purpose.

Introduction

From time immemorial there has been a conflict between science and religion and between secularism and fundamentalism. Gregg Easterbrook recently wrote a paper in 'Science' entitled 'Science and God: A Warming Trend,[1] and a number of scientists discussed the paper in a subsequent issue of the magazine. Ardhendu Sekhar Ghosh finds conclusions of modem physics strikingly analogous to those of the Vedanta[2]. Science and religion are being discussed in popuiar vernacular magazines. It may be interesting to note that the debate on scientific rational and revealed knowledge is as old as Kapil, the father of the oldest Indian Philosophical system, the Sankhaya. There is an excellent discussion of this problem in the Vedanta and the conclusions of the Vedanta are perennial.

Both Religion and Science began as an enquiry into human existence and with the same objective, viz, to get freedom from the limits of nature. For the better part of history, the same group of people used to profess both the disciplines. Narada[3] gave a catalogue of subjects he had learnt and it reads as follows :

Rig Veda, Yajur Veda, Sama Veda, the fourth and the fifth Vedas, eg, Atharva Veda and Itihasa and Puranas, grammar with contains the knowledge of all the Vedas, Spirit (of dead persons), number, heavenly bodies, economics, logic, ethics, etymology, theology, physics, administration and defence, cosmology, science of snakes and deities.

From the list, it is clear that the line between rationa and revealed knowledge was not clearly drawn. We had to wait for the evolution of the Indian philosophical systems for this demarcation. Kapil emphasised the importance of rational efforts in achieving liberation in the Sankhya philosophy. Gautam Buddha claimed that one does not need revealed knowledge for liberation from the cycles of births. With this background, the Vedanta delineated the limits of human intellectual pursuits in the fields of science and other logical activities and the role of religion in revealing the boundless reality which lies beyond the reach of our senses.

The Vedanta considered this issue from two perspectives and concluded that:

• Vedas and Science

The Vedas reveal supersensuous knowledge which is universal and eternal. Science explains the phenomenal world which is relative even when it is contained in the Vedas.

• Science and Religion

Science, philosophy, literature etc. supplement religion in the spread of knowledge. Such knowledge is impermanent and changes with time. In the spiritual matter, they are valid only so far as they follow the revealed knowledge. Science can not achieve God.

I will discuss the above two perspectives in some detail.

Vedas and Science

An enquiry into human existence on this earth has been going on since the dawn of civilization. The Vedas have described the evolution of life and the physical world poetically in different settings. Some of these have been quoted by Sri Sankaracharya while commenting on the Brahmasutra. They are[4] :

i. Brahman is Truth, Knowledge, Infinite (Tai .II. i). He wished, 'Let me be many; let me be born' (Tai .II. v). He created all this that exists (Tai .II. vi).

ii. In the beginning, O amiable one, all this was but existence. (Brahman) - One without a second (Ch VI ii I). He deliberated, 'I shall become many, I shall be born, ' He created light (Ch VI ii 3).
iii. In the beginning, all this was but the self -one without a second. Nothing else winked. He deliberated, 'Let me create the worlds' (Ai I i 1).
iv. From the self emerged space (Tai II i).
v. That existence (Brahman) created light (Ch VI ii 3).
vi. He created the vital force and from the vital force He created faith (Pr VI 4).
vii. He created these worlds - heaven, inter space, the earth and the nether world (Ai I i 2).
viii. In the beginning al/ this was but non-existence. From that sprang existence (Tai II vii).
ix. This was but non-existence in the beginning. That became existence. That became ready to be manifest (Ch III xix I).
x. With regard to that some say that the universe was non-existence before creation. But how can this be so, 0 amiable one? He said, 'How can existence emerge out of non-existence? This was but existence to be sure in the beginning' (Br 1. iv. 7).

These texts on the same issue in different Vedas are quite divergent and this creates confusion in the mind of the readers. Philosophers have raised questions about the diversity of views in the Vedas on a single issue, eg, the evolution of the phenomenal world. Since the Vedas are eternal and without any error, the nature and the se9uence of the evolution should have been the same in all of them. In resolving this point, Brahmasutra took a very bold and revolutionary position. It said that there is indeed diversity in the Vedas while describing the evolution of the world, but all the Vedas are unanimous as to the origin of the world, that it is Brahman - the One without a second - and there is no diversity of view in this respect. It may be possible to reconcile the descriptions of the evolution of nature in different Vedas but it is of not much significance. Vedas do not care to describe nature, their one and only goal is to make us know the origin of its evolution which is Brahman. 'The creation that is taught divergently with the help of clay, iron, sparks etc. is only a means for inculcating the Knowledge of Brahman, but there is no diversity whatsoever[5] .While dealing with supersensuous matter, the Vedas used the medium of common language and the experiences of the common people. Vedanta would not treat such descriptive matter as sacred and above review.

The Vedanta thus accepted the dichotomy between science and religion, relative and eternal knowledge in the text of the scripture and invited free scientific and rational enquiry into natural phenomena even when they were contained in the Vedas. By their very nature, Science and Religion differ in the way of arriving at conclusions. Religion deals with supersensuous matter and rely on authority of revealed truths and traditions and its truth is universal and eternal. Science relies on evidence and reasoning which are always open to challenge, so its truth is relative and tentative.[6]

The motivation for the pursuit of science and religion is, likewise, different. The scientific knowledge of the phenomenal world gives one power to control the nature The knower of Brahman attains the supreme' (Tai II i. The knower of the self transcends sorrow' (Ch VII i 3).

Science and Religion

The dichotomy between logical enquiry and revealed truths has another perspective. The Sankhya is probably the oldest philosophical system and was developed by Kapil who has been praised in the Vedas for his wisdom. The Yoga system of Patanjali is based on the Sankhya metaphysics. These two systems provide a complete programme to aspirants to achieve liberation from the cycles of the worldly changes, eg, birth, life and death. They accept the Vedas as a sacred authority but their systems do not intend to interpret the Vedas. They also hold views on Brahman, World, Soul Liberation etc, from logical point of view. The Sankhya shows that the existence of God can not be established. It believes that the world evolves out of nature and in course of time gets dissolved back into un-differentiated nature. There are innumerable Purusas or free Souls in the Sankhya system whereas in the Vedanta, the Supreme Brahman is one without a second. Given this position the Vedanta[7] observed that this extremely sublime subject matter concerned with the reality of the cause of the universe and leading to the goal of liberation, can not even be guessed without the help of the Vedas. It can not be known either through perception, being devoid of forms or through inferences, being devoid of grounds of inference. Science is based on observations on the phenomenal world which is going through transformation all the while in accordance with the law of conservation of energy. But science can not know the existence underlying these transformations which, by definition, remain conserved and unchanged.[8] In this pursuit for liberation from the yoke of nature the Sankhya and the Yoga are conducive to the Knowledge of Reality through inference and supporting reasons. They have their application so far as those features are concerned which are not antagonistic to the Vedas. For instance. the absolute Purusa that is well known in such Upanishadic texts as 'For, this infinite Being is unattached' (Br IV III 5) is preached by the Sankhya when they affirm that their Purusa (individual self) is without any quality. Similarly the followers of the Yoga. when instructing about the qualification of monks etc. subscribe to the path of detachment as it is well known from the Upanishadic text. 'Then there is the monk with his discoloured (ochre) cloth, shauen head, and non-acceptance of all gifts (Jabala, 5).' But the knowledge of reality springs from the Upanishadic text alone as is stated in such passages as

• One who is not uersed in the Vedas can not reflect on the Great Entity (Tai Br III X'II 9.7).
• I ask you of that Infinite Being known only from the Upanisadas (Br III ix 26).
• Who euery knew here that THING directly, from which this diuerse creation originated and who euer spoke of THIS in this world? The gods were later than this creation. So how can anyone know THAT from which creation originated? (R. V I xxx 6).

Reasoning that has no Vedic foundation and springs from the imagination of persons, lacks conclusiveness, for men's conjecture has no limit. What is proved by some is later refuted by others. Further, sages hold divergent views: Kapil holds that Prakriti is an independent entity and is the material cause of creation and that there are many Purusas, whereas Manu holds the Vedic view that there is one supreme soul - the Absolute Brahman, who alone is responsible for the diverse creation. Science will continue to develop and discover the secrets of nature without an end, but the mystery of the absolute being will always remain beyond its reach. The Vedanta thus reaffirms that science and logical analysis is the way to know nature, whereas, religion alone can lead us to freedom from the limits of nature. The Vedanta liberated the Hindu Psyche, once and for all, from the fear that the scripture binds us to some primitive knowledge as the final truth and that free scientific enquiry is materialism and stands against religion. It will be shown later that according to the Vedanta, scientific knowledge is a part of the total knowledge which, however, is perceived by the Cosmic Intellect alone.

Science and religion continued to exist harmoniously until quite late in the history. In recent times, science has made rapid progress in uncovering many secrets of nature and has established an identity of its own, separate from the Vedas. Application of science to technology, production and other economic activities has ushered in an age of prosperity and growth. The same train, however, brought a threat of unleashing destructive forces which can damage the ecosystem and even eradicate life from the face of the earth. By its veri nature science is treated in fragments and scientific knowledge is changing all the time. Science uses specialised symbols and languages and thereby creates a barrier between the experts and the common men. The separation of science from religion and humanities coupled with the threat from technology has created some tension in the minds of people. As a result, there is an irrational resistance to science from them, because they feel helpless and isolated from the affairs of the world, although they are the ones who have to suffer all the consequences of the decisions taken by the experts in science, technology, medicine, politics and economy. Original scientific and technical work can not be reported in the language of the common people. It is the function of religion to come forward and reconcile the new knowledge into the body of total knowledge and disseminate them to the people in the language they can understand. When a scientist is doing this work, he is really serving the purpose of religion. Religion has not been very successful in this role and in many occasions has taken a negative stand trying to suppress free enquiry in the name of faith. I would like to conclude this note with a brief discussion of the Vedantic concepts regarding the structure of the mind in order to bring out the natural role of religion in guiding humanity in its pursuit of knowledge.

Human mind is complex and we do not have access to the whole of it except to a small fraction which is[9] conscious and all the time gathering data of the world around us by the sense organs and deciding on the course of action by rational scientific analysis. We attach our ego to it. The mind also gathers data on the internal functioning of the body and goes on making small adjustments in the operation of their functions. We hardly know this subconscious mind. There is a super conscious cosmic intellect, the 'Mahat' of the Sankhya or the 'Mahan Atma' of the Vedanta; and the religious experience 'is possible when a door opens and connects the conscious mind to the super conscious. This cosmic intellect is the first born[10] and is the highest basis of intellect of all beings. Sri Sankaracharya quoted from the Mahabharata its many attributes like : power of thinking, pervasive presentiment to determine the future, soul and the refuge of all enjoyable things, intellectual power of determining the present, fame, rulership, intention, expression, consciousness and memory of the past (Mbh XIIIx Il). Our field of vision is narrow and we cannot see the future. The Cosmic Intellect has no such limitations. It can reconcile the apparent conflict when knowledge is evolving, sometimes in faltering strides, through different channels : the subconscious, conscious and super conscious. Perhaps, all events occur at its bidding. We require a visionary, a poet, a scientist, a philosopher, a story teller all moulded in one person who again has free access to the Cosmic Mind and grasps the totality of human knowledge. Through them, the power of religion, broadened and purified, is going to penetrate every part of human life and every pore of our society.[11]

Notes

1. Gregg Easterbrook. 'Science and God: A warming Trend.' Science, August 15,1997.

2. Ardhendu Sekhar Ghosh. 'Parallelism between Physics and Vedanta.' Prabuddha Bharat, vol 2, September 1997.

3. Ch. VII i 2.

4. Swami Gambhirananda. 'Brahma Sutra Bhashya of Sri Sankaracharya.' B.S I iv 14.

5. Sri Gaurapada Acharya : Mil 11I15.

This refers to that famous instructions of the Upanisad 'Thou art THAT Swetaketu' in which examples were drawn from familiar objects like clay, iron and sparks to illustrate that all articles made of clay etc. are different only in name and form but remain clay. Likewise, all phenomena are different in name and form but they all have only Brahman as the reality.

6. Edgar Pearlstein -letter to editor. Science, September 12, 1977.

7. B.S. II i 1. 2, 3, 6,11.

8. Richard P. Feynman, Robert B. Leighton, Mathew Sands. The Feynman Lectures on Physics 4.l.

9. Complete work of Swami Vivekananda. vol 2, p 13,447.

10. B.S. I iv 1.

11. Swami Vivekananda, 'The Necessity of Reliqion.' CW, vol 2, p 49.

Abbreviations

Ai	Aitareya Upanishad
Ai Br	Aitareya Brahmana
Br	Brhadaranyaka Upanisadm
BS	Brahma Sutra
Ch	Chandogya Upanishad
Ma	Mandukya Karika
Mbh	Mahabharata
Pr	Prasna Upanishad
RV	Rg Veda
Tai	Taittiriya Upanishad

Knowledge Management

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INTRODUCTION

Finns have long known about increasing role that knowledge plays in economic processes. Along with traditional resources of land, labour and capital, knowledge had always been important while detenning a firm's competitive edge. Firms have always been oriented towards accumulating and applying knowledge to create economic value and competitive advantage. An automatic increase in knowledge and an incentive to search for new knowledge are 'built-in' into the very nature of a firm's competitiveness[1]. Recently, there is an upsurge of interest in management of knowledge. More and more organisations are talking about building up strengths in knowledge management practices today. Perhaps, the development and deployment of Information Technology has been the strongest immediate source responsible for such a shift. When one expands the coverage of knowledge to macro levels, a nation can be considered to be a large enterprise with broader interests in economic health, growth rate, global competitiveness, and welfare of people and exploitation of resources. Most of the concepts of knowledge management thus become applicable equally well at enterprise level and national level. Education and advances in knowledge are as important as capital and natural resources in contributing to the economic growth of the nation[2],

Prusak[3] has listed the following four broad reasons that seem to be playing a significant role in this renewed interest in knowledge management:

(a) The globalisation of the economy which is putting terrific pressure on firms to have increased adaptability, innovation and process speed.

(b) The awareness of the value of specialised knowledge that has embedded in organisational processes and routines in coping with the above pressure.

(c) The awareness that knowledge is a distinct factor of production and its role in the growing book to market ratios within the knowledge-based industries.

(d) Low cost network computing which has become a powerful tool to work and learn together.

Knowledge management has recently emerged as a powerful concept to provide a firm with sustained competitive advantage. Knowledge management deals with knowledge as a corporate resource and works around establishing the policies and practices for creating and deploying the firm's intellectual assets. This in turn can improve the whole range of organisation performance characteristics over a longer period.

CHANGING PARADIGM OF MODERN MANAGEMENT

Due to the environmental trends as suggested by Prusak, as the organisations adapt to the needs of the current world of business, many aspects of management are being questioned. Sparrow[4] has indicated following trends emerging in management in organisations.

(i) A movement from an emphasis on decision outcomes to a greater appreciation of decision process.
(ii) Recognising that decision process involves more than logic.
(iii) Recognising the centrality of perceptions and misperceptions in organisational decision making.
(iv) Avoiding treating implementation as afterthought.
(v) Acceptance of chaos.
(vi) Recognising that organisational capability requires organisation learning.

The above trends clearly indicate a paradigm shift from certainty to uncertainty through current management education emphasis on the sciences of management manifests a drive for certainty and the nonrecognition of the value of ambiguity. However, the changing environment demands a greater emphasis on thinking and reflecting, continuous learning and focus on people and socio-technical systems for sustained growth of the organisation. The concept of knowledge management has emerged from these very needs of the organisation.

DEFINING KNOWLEDGE

The term knowledge in not broad enough that covers all the aspects of mental material that are used as sources of information in a particular decision or action[4]. The dominant approaches for explaining the actual source of knowledge; rationalism and empiricism differ significantly. While, western philosophy is more oriented towards empiricism, the eastern philosophy seems to be inclined towards the individual experiences where ideals, values and emotions play a dominant role. Rationalism argues that true knowledge is not the product of sensing experience but some mental process. There exists an apriori knowledge that does not need to be justified by sensory experiences. In contrast, empiricism claims that there is no apriori knowledge and that the only source of knowledge is sensory experiences. Experimental science is the classical example of this view. Another fundamental difference lies in the methods by which knowledge is obtained. As per rationalism, knowledge can be attained deductively by appealing to mental constructs, such as concepts, laws or theories. Empiricism contends that knowledge is derived inductively from particular sensory experience.

Plato was the first one to build an elaborate structure of thought on knowledge from rationalistic perspective. He proposed the world as shadow of perfect world of 'ideas' which can be known through pure reasons. Aristotle stressed the importance of observation and the clear verification of individual sensor perception. Many other philosophers such as Kant, Hagel and Marx tried to synthesise the two approaches. Polanyi's distinction between 'tacit' and 'explicit' knowledge is also an attempt to synthesise the two perspectives[5]. Tacit knowledge, he explained, is personal, context specific, and therefore, hard to articulate and communicate. Explicit or codified knowledge refers to the knowledge that is transmittable in formal systematic language. He contended that human beings acquire knowledge by actively creating and organising their own experiences. Thus, the portion of knowledge that can be articulated (ie, explicit knowledge) is only the tip of the iceberg of the entire body of knowledge.

The fine arts, sports, handicrafts, political and management skills are some of the examples of tacit knowledge which are difficult to articulate. Scientific and engineering knowledge is explicit knowledge by its very definition. Once the knowledge is made explicit, it can be preserved for a longer time and also can be transferred enabling generation of new knowledge through further interactions. However, tacit knowledge, since it lies within an individual's head, dies along with the person. The only way to preserve this knowledge is to embed it in the social system. The tremendous progress made by west in technology is due to their extra emphasis on codification of knowledge to make it explicit. India on the other hand lost most of its treasure of knowledge, especially in the field of medicine, 'metallurgy, mathematics, astronomy, aeronautics and propulsion by neglecting this aspect.

EVOLUTION OF KNOWLEDGE MANAGEMENT

Leaving behind the philosophical part of knowledge, most of the economic theories have treated knowledge as an important factor in economic phenomena. Economists realised the role of knowledge long back and in fact it is the interest of economist in knowledge, which has led to the new management thought of knowledge management. Alfred Marshall, the noted economist was the first one to state explicitly the importance of knowledge in economic affairs.

'Capital consists in a great part of knowledge and organisation ... knowledge is our most powerful engine of production ... organisation aids knowledge.'[6]

However, this school of thought treated knowledge as a stock of existing knowledge represented by the price information. He assumed that every firm has same fixed knowledge that enables profit maximisation. Thus, they neglected the considerable amount of tacit and explicit knowledge available with firm which could not be represented in the form of price. They also missed that the new knowledge is also created during the utilisation of knowledge.

Von Hayek[7] and Schumpeter[8] pointed out that knowledge is 'subjective' and should not be treated as fixed. They tried to describe the dynamics of economic change by focusing their attention to the unique knowledge held by each economic subject rather than the common knowledge shared by all economic subjects. Hayek classified the knowledge into scientific knowledge and the context specific knowledge. However, he failed in developing a dynamic theory of market and ended up with efficient utilisation of existing knowledge. Schumpeter, however, emphasised on the importance of combination of explicit knowledge in terms of new products, production methods and materials.

Penrose[1], Nelson[9] and Winter[10] treated firm as knowledge repository. Penrose 'considered planning process, as central to firm's economic growth. She argued that corporate planners create images of mental models of the firm and its environment by appraising the firm's strengths and weaknesses in terms of its products, services and opportunities and these images form the experiences and knowledge within the firm -.Nelson and Winter suggested that such knowledge is stored as regular and behavioral patterns of the business firms. Their recognition that the essence of technology is this knowledge led people to think about the relationship of creation of technological knowledge to broader organisational process.

On one side economists' treatment of knowledge had been towards 'scientification of knowledge' ie, treating it more as explicit, the management theories had strong orientation towards humanisation of knowledge, ie, the 'knowledge embedded in management practices. For example, on one side pioneering work of Taylor on time and motion study created economic value through scientification of knowledge, the work of Mayo and Weick (Hawthorne experiment) brought out the organisational culture and behavioral role in economic process.

Barnard[11] synthesised the two approaches. He viewed knowledge in two different contents; logical, linguistic content and behavioral non-linguistic content. Leaders create values, beliefs, and ideas in order to maintain the soundness of knowledge systems within the organisations. Barnard emphasises on the need of integration of the logical and non-logical processes of human mental activity. However, he left the organisational process of knowledge creation unexplained. Simon saw the essential functions of executives as that of decision making, and hence, viewed the organisation as information processing machine and disregarded the tacit knowledge as noise. He proposed that business organisations react to the environment mainly by adjusting the information processing structure. Later researchers, except a few, also put more emphasis on scientific knowledge in business rather than implicit knowledge in human beings.

Nonaka and Tekeuchi[12] point out three common shortcomings with this line of research.

(i) These approaches do not pay enough attention to the potential and creativity of human beings.
(ii) Human beings in most cases are seen as information processor and not as information creators.
(iii) Organisations are portrayed as passive in their relation to the environment.

Peter Drucker[13] was the first one to notice the sign of great transformation around 1960 who coined the terms like 'knowledge worker' and 'knowledge society' where organisations will be the creator of knowledge and the knowledge will be basic economic resource. He suggested that one of the greatest challenges for every organisation in the knowledge society is to build systematic practices for managing a self-transformation through abandoning old and obsolete knowledge, and learn to create new things through continuous learning and continuous innovation, thus increasing the knowledge workers productivity[14].

Creating these competencies in the organisation is the main objective of knowledge management.

KNOWLEDGE CREATING PROCESS

The growing interest in knowledge management is due to various reasons. Practitioners tend to emphasise large number of adhoc factors such as highly dynamic environment, globalisation of markets, global integration and networking of organisations and the revolution in information technology making the information of knowledge flow possible at a high speed. However, the root cause of this interest appears to be the growing knowledge-intensity of products and services, and the corresponding need to create more and more new knowledge for improved products and sustainable competitive advantage.

Nonaka and Takeuchi explained the theory of organisational knowledge creation in detail[12]. They explained the knowledge creation as a process mobilised in conversion of tacit knowledge at different entity levels, ie, at individual level, group level, organisation and interorganisational levels. Fig 1 presents the knowledge creation spiral which emerges when the interaction between tacit and explicit knowledge is elevated dynamically from lower to higher logical levels.

Strictly speaking organisations cannot create knowledge. The knowledge is created by individuals only. But organisations support these creative individuals and provide a context for them to create knowledge. Therefore, the organisational knowledge creation is a process of identifying, creating and supporting creative individuals and amplification and crystallisation of their knowledge as a part of knowledge network of the organisation.

The four modes of knowledge conversion suggested by Nonaka and Takeuchi are presented in Fig 2 as a 2 × 2 matrix. They named these four modes of conversion as socialization (tacit to tacit), externalization (tacit to explicit), combination (explicit to explicit) and internalization (explicit to tacit).

An individual can acquire tacit knowledge even without using language, just by observing others doing things and by sharing their experiences. On the job training, brainstorming and information meetings and discussions on specific training, or on specific problems are the part of socialisation process where tacit knowledge of an individual is transferred to others in the same form. Interactions with customers before product development and after market introduction are best examples of sharing tacit knowledge and creating ideas for improvement.

Externalization is the process of articulating the tacit knowledge into explicit with the help of metaphor concepts, analogies, hypothesis or models, although it is often inadequate and insufficient. Among the four modes of knowledge conversion, externalization is the most important in knowledge creation as it creates new, explicit concepts from the tacit knowledge.

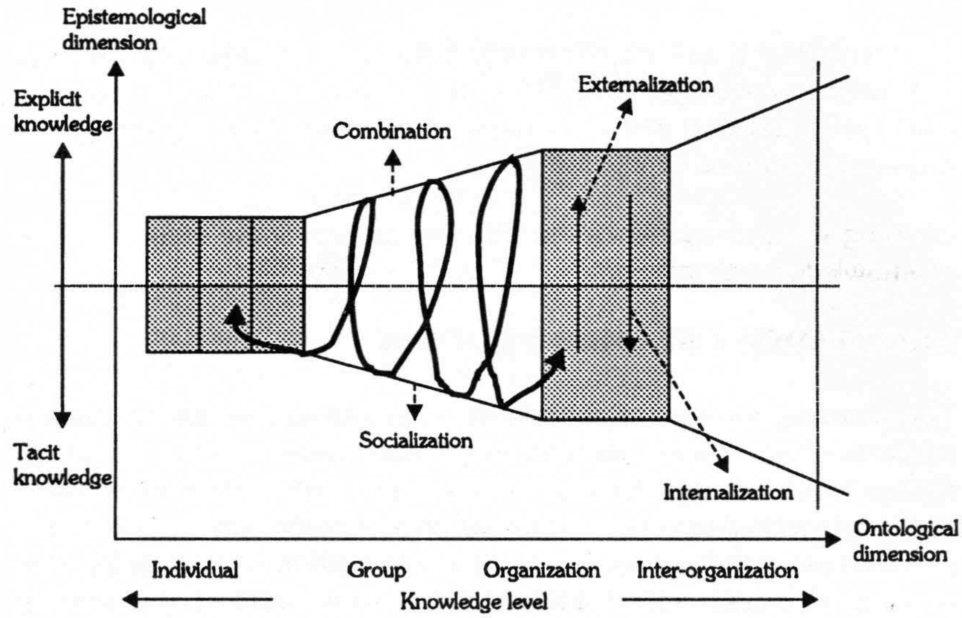

Fig 1 Spiral of organizational knowledge creation

	Tacit Knowledge	Explicit Knowledge
From \ **To**		
Tacit Knowledge	(Socialization) **Sympathized Knowledge**	(Externalization) **Conceptual Knowledge**
Explicit Knowledge	(Internalization) **Operational Knowledge**	(Combination) **Systemic Knowledge**

Fig 2 Contents of knowledge created by the four modes of knowledge conversion[12]

Combination is a process of systemizing concepts into a knowledge system. Individual exchange and combine knowledge through media such as documents conversation and networks. Reconfiguration of exiting knowledge, sorting, adding, combining and categorizing of explicit knowledge can lead to new knowledge.

Internalization is a process similar to 'learning be doing'. When experiences through all the other modes are internalized into individuals tacit knowledge base in the form of mental models or technical know-how they become valuable assets. Documentation is an essential part of internalization process. Case studies, stories and symbols help the process of internalisation.

How the entire process of knowledge creation and growth works can be explained with of the example of missile program (Fig 3). Lining the rocket motors to protect from high temperature gases is a high technology skill. This technology was available in partially explicit and partially tacit form at a number of work centres within the country. This knowledge was more of development type and was also not exactly uniform at all the places. While DRDL, Hyderabad knew the lining using composite materials, VSSC,Trivandrum had more knowledge with motor lining using rubber. Similarly, lIT Nadras had good background of mathematical modelling of materials, structure and curing process. One small-scale industry, Resins and Allied Plastics of

Vijayawada, had been doing occasional rubber lining for ISRO. High Energy Materials Research Laboratory (HEMRL), Pune knew about casting of propellant into a lined motor and their interactions. The project team, once recognising the knowledge base, organised the interactions among various knowledge centres through group discussions, codification of knowledge, training of technicians, documenting QA procedures and evolving acceptance standards. With this, knowledge of the entire process starting from raw material, equipment and process that make up the technology package was made available to the Vijayawada firm which was identified as the production agency. In this process, it was a pleasant experience to see that not only all the partners got themselves enriched with incremental knowledge in their respective areas, but also the Vijayawada industry was able to further upgrade this acquired knowledge within a year, and bring out a product superior to the one for which it got the technology. This demonstrated the synergistic interaction of knowledge workers and knowledge work centres.

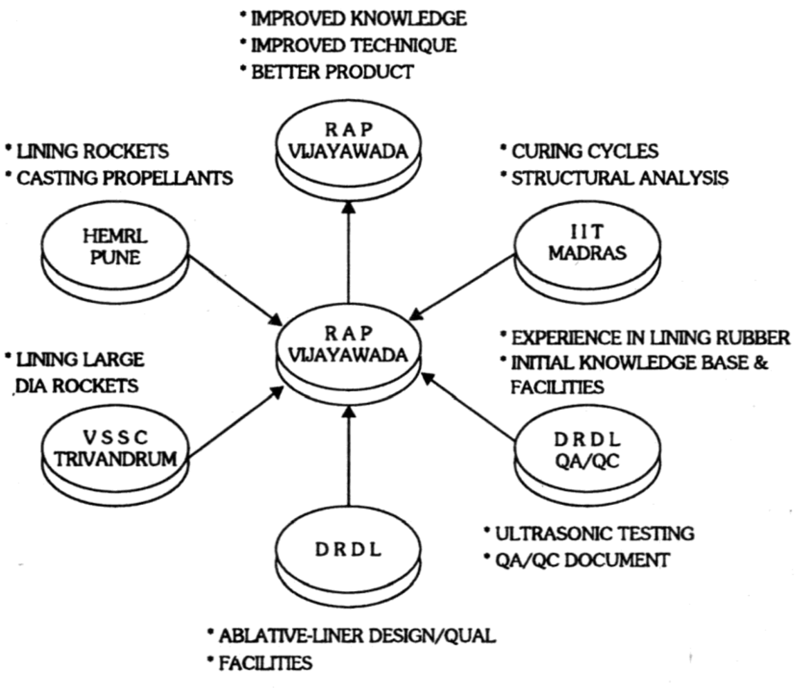

Fig 3 Knowledge growth in rocket motor lining industry

A NEW MODEL FOR KNOWLEDGE MANAGEMENT

Presently, knowledge management is seen as the bundle of processes and practices to effectively create, develop and exploit the knowledge in a firm. A knowledge management system in an organisation identifies the knowledge requirements of the organisation for its business objectives, prioritises it in terms of business relevance, establishes knowledge creation process and practices, establishes knowledge capture, exploitation and knowledge protection mechanism and also the required infrastructure for the same. However, there is striking contrast observed between the perception of eastern and western systems for knowledge management. Cohen[15] listed these contrasts which look roughly like this.

West	East
Focus of explicit knowledge	Focus on tacit knowledge
Reuse of knowledge	Creation of knowledge
Knowledge projects	Knowledge culture
Knowledge markets	Knowledge communities
Management and measurement	Nurturing knowledge
Near term gain	Long-term advantages

To explain the basic concept of knowledge management, Sen and Prahlada'v developed a model, which is shown in Fig 4.

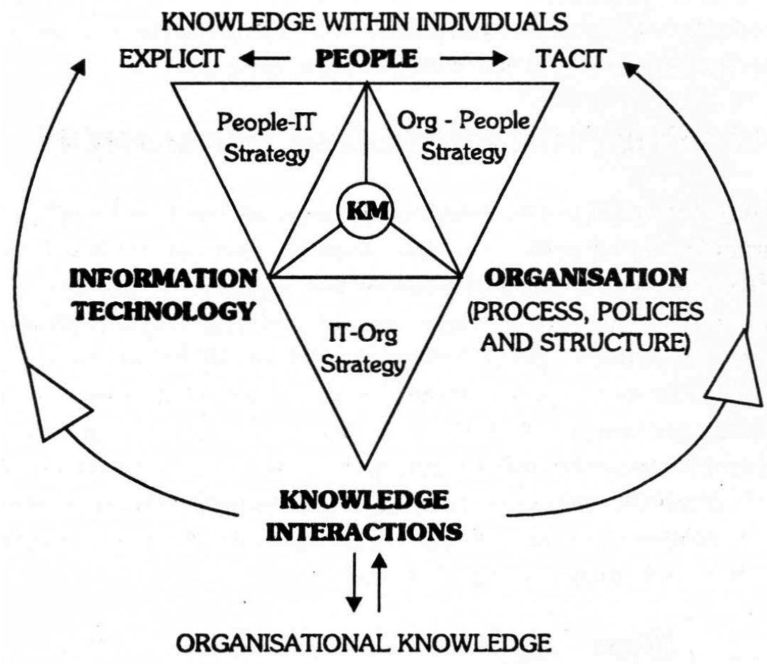

Fig 4 Framework for knowledge management

The knowledge in an organisation resides mainly in three forms at three different entities. The natural place for knowledge to reside is within individuals because only individuals can create knowledge. Organisation can support the creative individuals and provide contexts for them to create knowledge. Knowledge also resides in the organisation in the form of the organisation structure, policies and practices. The vision, mission, practices, and value system of the organisation gets evolved through the churning of loads of environmental information and years of experiences.

The third place where knowledge can reside is the IT infrastructure where the knowledge is stored in the form of either information or explicit knowledge. A knowledge management system in an organisation should be developed around these three basic dimensions.

Further, the knowledge in individuals can be classified into two subdimensions; the explicit knowledge that can be articulated and codified, and tacit knowledge which is difficult to be articulated, and hence, remains in the heads of the individuals, as suggested by Polanyi.

Similarly, the organisational knowledge also has two exclusive dimensions — the tacit knowledge of the individual and groups in the form of vision, mission, policies, culture and value system. The other sub-dimension deals with the organisation, structure, norms and practices to facilitate knowledge interaction between the knowledge of individuals. The knowledge, which resides in the Information Technology, could be in the form of databases, repository or codified explicit knowledge of individuals and groups. Information technology tools are very effective in handling, storing and protecting the explicit knowledge of individuais or groups at one end, and disseminating and communicating the explicit knowledge, thus creating knowledge interactions at other end. Thus, explicit knowledge of people through the help of IT and tacit knowledge of the people with the help of organisation create knowledge interactions (explicit-explicit, explicittacit, and tacit-tacit interactions) which result in amplification of the knowledge of individuals and also participates in the form of organisational knowledge.

Based on the model three main knowledge management strategies could be suggested while developing a knowledge management system in any organisation.

(i) People-Organisation strategy
(ii) IT-People strategy
(iii) Organisation-IT strategy

These strategies are discussed subsequently in the paper while evolving the KM strategies for different types of organisations.

KNOWLEDGE MANAGEMENT STRATEGIES FOR DIFFERENT ORGANISATIONS

While building a knowledge management system in organisations, there is no single approach that fits well in all types of organisations. Based on the KM model suggested by Sen and Prahlada[16], a knowledge management system can be evolved for a particular organisation as per its specific requirement and strategic intent. Hansen, Nohria and Tierney[17] have suggested that there are basically two strategies for incorporating knowledge management system in the organisation, namely codification and personalisation. The codification strategy in an IT intensive strategy which is required for the organisations whose products are rich in explicit knowledge. In this approach knowledge in carefully codified and stored in databases where it can be accessed and used easily by anyone in the company. The personalisation strategy is for the industries with tacit knowledge intensive products. Here the knowledge is usually closely tied to the person or expert who developed it. The processes are established in the organisation to share this knowledge through person to person interactions.

Sarvary[18] suggests two markedly different approaches for building knowledge management system in a consultancy industry. The first one defined as the bottom up decentralised knowledge management system, which emerges from the initiative of the firm's consultants with management, involves only loose coordination of the processes. These systems typically put more emphasis on people rather than on information technology. Obviously, here he refers to personalisation strategy as suggested by Hansen, et al. Sarvary suggests that such a system has more drawbacks. Firstly it is reactive. People are not pushed to build knowledge because it takes time away from engagements while providing no guaranteed return. They have little incentive to do research. Rather they wait until sufficient information is available before they sit down and draw some conclusion. Also the integration of information obtained from outside leaves the firm vulnerable because of knowledge building units are in the field and their knowledge is available to all. Finally, the lack of oversight of the inflow of experience may lead to superficial understanding. Hence, such a system might not be the best for triggering new ideas or revelations that lead to breakthroughs. However, Sen and Prahlada suggest this strategy most suitable for research intensive organisations.

The second type of system consists of relatively centralised system thatis built and managed from the top. These systems are generally based on advanced information technology. They typically establish the network through a large-scale organisation, so job also consists of synthesizing and distributing the firm's knowledge. The main advantage of centralised systems is that they provide the opportunity for visionary breakthroughs. The main disadvantage of the system is that they are expensive and the benefits are very hard to measure.

Zack[19] has discussed in detail the development of knowledge strategy in the firm. He suggests that knowledge strategy describes the overall approach an organisation intends to take to align its knowledge resources and capabilities to the intellectual requirements of its strategy. It can be described along two dimensions, reflecting its degree of aggressiveness. The first dimension comprises the organisation's need to increase its knowledge in particular areas as against the opportunity it may have to leverage the existing underutilized knowledge resources, ie, the extent to which the firm is primarily a creator or a user of knowledge. The second dimension addresses whether the primary sources of knowledge are internal or external. Together these characteristics help a firm to describe and formulate its current and desired knowledge strategy.

Extending this discussion further, Sen and Prahlada[16] suggested different strategies suitable for different organisations based on their primary mission (Fig 6).

People-Organisation Strategy

This strategy is most suitable for the organisations whose products are rich in tacit knowledge such as advertising orqanisetions.sports teams or research organisations. The organisations involved in creating knowledge through the internal resources need shared concepts and beliefs, which are of tacit nature. The tacit-tacit knowledge interactions that are required to create this can be accelerated through organisational processes. Quadrangle 1 in Fig 5 represents these organisations. Creativity is the essence of such organisations. Team building, free and open discussions, good interpersonal relationship, close associations, on-the-job training, etc are some of the processes for these organisations. Usually it is difficult to establish these practices on larger scale that too with people with specialist skills. Hence, these organisations are bound to be small. Large organisations can be broken in smaller teams and groups for better outputs. Human skills are of utmost importance in such organisations. Proactive management methods are required to implement such a strategy. This strategy is to personalisation strategy, as suggested by Hansen, et al.

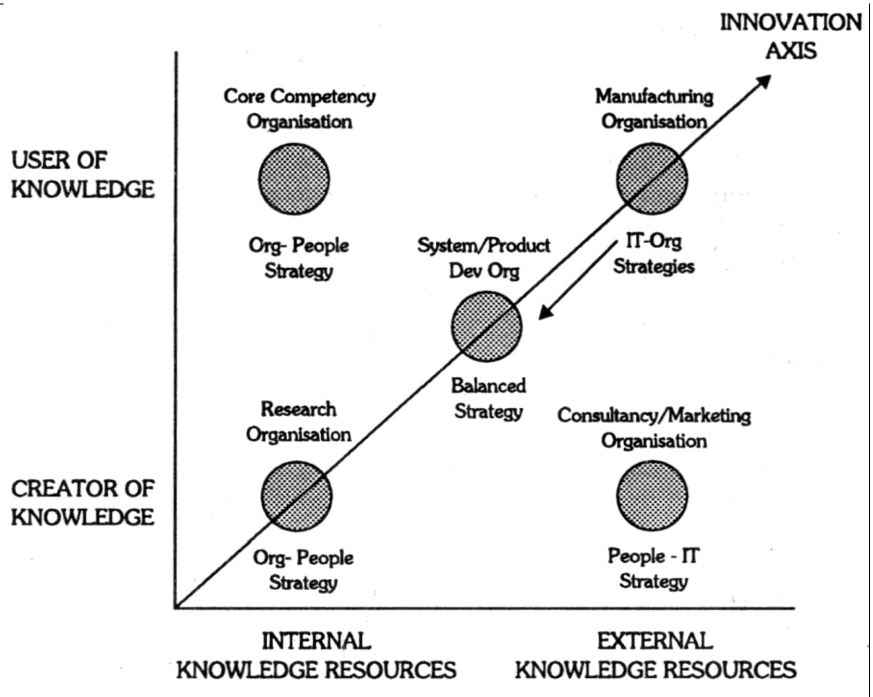

Fig 5 Different knowledge strategies for organisations

People-IT Strategy

Many times knowledge management is misunderstood by extensive networking and exchange of information using latest IT-tools. It is because of enormous potential of IT while handling the explicit knowledge. IT has broken all the boundaries of organisations and nations and has made available to individuals the enormous explicit knowledge spread across the world at a very low cost, resulting in multifold growth in knowledge interactions. While on one hand these changes have made the technology to grow at a very fast pace, on the other hand availability of enormous information has made the decision process extremely difficult. Designing a custom-made, userfriendly knowledge management system is a challenge while implementing this strategy. Perhaps that is the reason people have started doubting the returns on IT expenditure. Most of the organisations are going for this strategy, as it appears to be an easy one. The strategy is most suitable if the organisation is the user of external knowledge such as manufacturing organisations. Since technology is explicit portion of the scientific knowledge, hence, this strategy is highly useful in acquisition, absorption and dissemination of high-technology information in very large multinational manufacturing and marketing organisations.

IT — Organisation Strategy

Any information can become knowledge only when processed in human mind. Since this strategy does not involve people directly, it is more an information strategy, or an higher form of automation strategy for the organisation, than that of a knowledge strategy. This is more suitable for the organisations where information provides the competitive advantage of the firm such as service organisations and software industries. Enterprise Resource Planning (ERP) and Management Information System (MIS) can be put' under this category. This strategy may provide the organisation with the ability to improve the time cycle performance for any activity.

As indicated in Fig 6, the system or product development organisations need to follow a balanced strategy for knowledge management. This means all the three strategies are required in a proper proportion. It is because the system development organisation is the creator as well as the user of knowledge. They need to create the core competencies to sustain, they need to utilise the existing knowledge wherever available and they also need to innovate continuously.

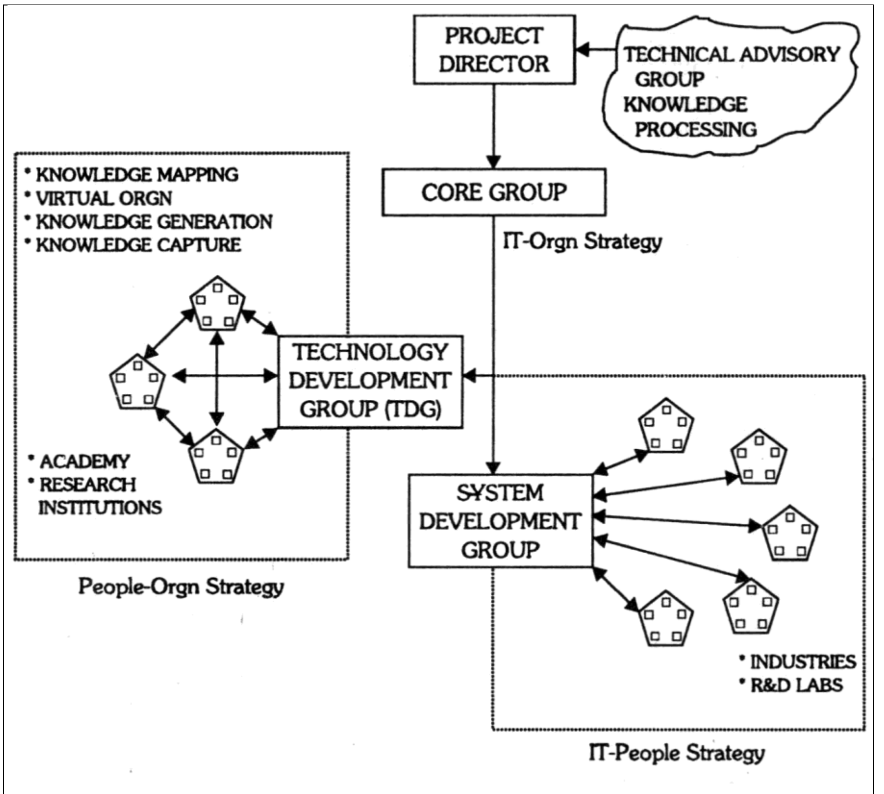

Fig 6 Knowledge management for development of 'State-of-the Art' high-tech systems

KNOWLEDGE MANAGEMENT IN R&D ORGANISATIONS

R&D management ideally is the management of knowledge over the total technology life cycle of a product rather than mere development of a product. R&D management processes developed in the past deal with concepts, technique and tools for managing research as an investment portfolio of a firm. These models focussed on creation and diffusion of knowledge internal to the firm. However, today R&D is also about managing the knowledge external to the firm. The reasons are obvious. Continuously reducing life cycle of technology, increasing complexity and multi-disciplinary nature of technology, huge resource requirement for generation of new technologies, increasing awareness about intellectual property rights, and availability of powerful IT tools are the main factors behind this paradigm shift.

The first generation R&D management during 1960s placed great emphasis on individual creativity and undertaking of scientific discovery. The scientific freedom of the research was considered more important than the relevance and accountability of the research itself. The justification for undertaking R&D projects was based on the perceived importance of new knowledge generation. The second generation of R&D management emphasised the fusion of multidisciplinary technology and the need for professional project selection and management. Researchers were encouraged to take up only those projects, which could deliver the tangible results within a specified period. Quantitative methods were employed to ascertain the contribution of R&D on a project to maximise economic returns to the organisations. The treatment of knowledge emphasised on individual efforts and codification of knowledge. The third generation of R&D according to Rouseel, Saad and Erikson[20]? created linkages between corporate goals and R&D strategies. The R&D management processes were based on strategic and operational functions of the orgnisation. All these models did not focus on integration of global knowledge with R&D management process.

Liyanage, Greenfield and Don[21] have suggested the need for a fourth generation R&D management model to deal with the knowledge that resides in organisational and network boundaries and contribute to the knowledge capital of the organisation. They call it 'boundary' knowledge and define it other than explicit and tacit knowledge. The new model is required to address the following management processes:

• To absorb and integrate external knowledge.

• To create organisational ability to continuously learn and generate new knowledge exponentially.

• To integrate complimentary skills and resources for cost effective knowledge management.

• To deal with knowledge intellectual assets and manage it as corporate resource.

Thus, the next generation of R&D organisation need to integrate the R&D management processes with knowledge management to manage the internal and external knowledge as corporate resource, and integration of the knowledge to create economic and social value. DRDL, Hyderabad has set up a Knowledge Management Centre to focus on this aspect in a more scientific manner for their future R&D programs. As explained earlier, a system development laboratory needs to have a balanced knowledge management strategy. Fig 5 shows a broad knowledge management system using which they are in the process of establishing a Hypersonic Technology Development Program.

NATIONWIDE KNOWLEDGE MANAGEMENT

Till now most of the work on knowledge management concentrates upon understanding and building the concept from an organisation's point of view. However, this concept, if raised to nation's level, can provide the synergy for economic development of the nation and improve the quality of its people. Prahlada and Sen22 suggested the concept of 'Nationwide Knowledge Management' and a framework to build such a system. The basic framework is shown in Fig 7. In this work they have attempted to evolve the knowledge creation and knowledge exploitation strategies through the strategic management analysis of the nation. Six main strategies suggested by them are

(i) Intellectual property rights
(ii) R&D through knowledge network
(iii) Development of human resource
(iv) Encouraging venture capital for knowledge exploitation
(v) Market development
(vi) Technology acquisition
(vii) Need based infrastructure including IT.

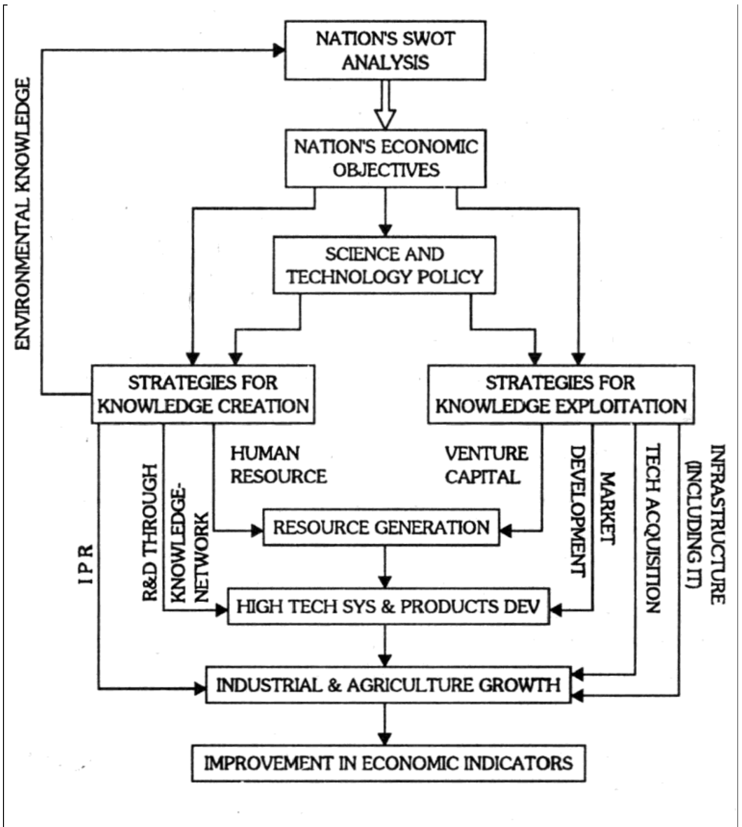

Fig 7 Framework for nationwide knowledge management

CONCLUSION

Recently, there has been an exponential growth of the published literature on knowledge management. While some of the people find nothing new in knowledge management and find this as another 'fad' propagated by management researchers, others feel that it is one of the most powerful concepts emerging in the recent times.

We strongly feel that systematic and effective management of knowledge is essential to attain and sustain the progress of an organisation or a nation. Each organisation needs a unique knowledge management system configured based on its business objectives and cultural background. One such opportunity and challenge is focused here.

We can take the example of software industry in our country, which needs a nationwide effort to create advantage for the country through this concept. There is a tremendous demand for software packages for design, analysis, and simulation in many engineering areas. To meet this need, we procure these packages from foreign sources at an enormous cost. It is ironical that many of these packages are being designed by our own engineers abroad or by Indian companies. However, the total knowledge management is in the hands of foreign companies. These companies constantly upgrade these software packages, again using many Indian engineers. There exists a perpetual demand to buy newer and newer versions of these packages from these companies, as they are all proprietary products.

One can consider a system of Nationwide Knowledge Management configured for Indian society to create and harness the knowledge of our own people and start creating and using our own software packages. The core competency definitely exists in our R&D laboratories, academic institutions, software houses and industries.

Fig 8 puts this scenario as a challenge before all the India knowledge workers.

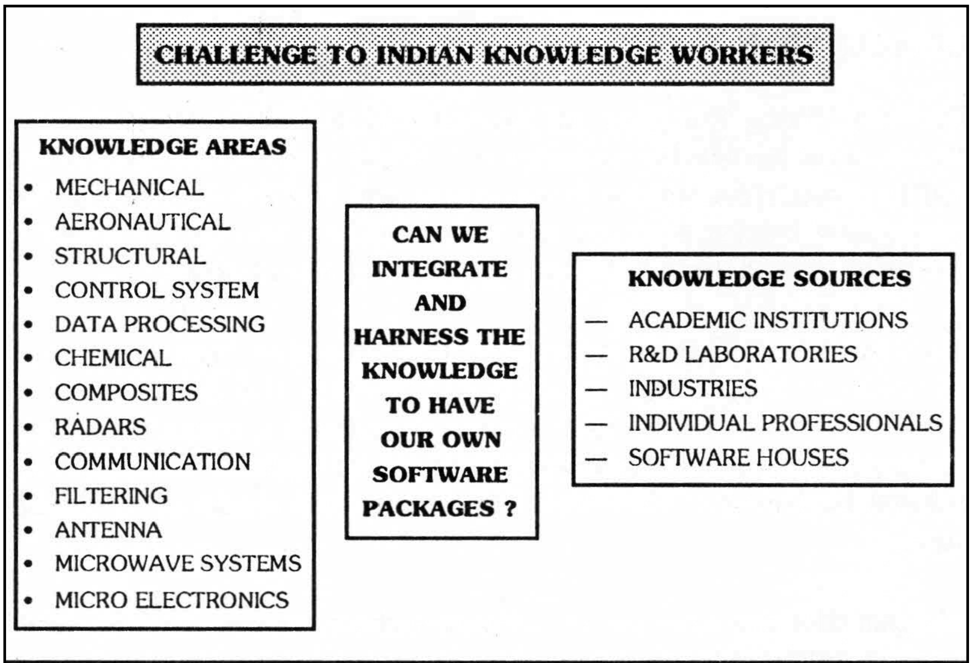

Fig 8 Can we do it ?

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What Ails the Power Sector?

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Politics and the games the politicians play. Iwill come to this later but let me at the outset thank the organisers and the Institution of Engineers for the opportunity given to me for talking on a subject that is bothering the ntire country for almost a decade or ever since this crucial sector was thrown open to the private investors with sops that were never considered necessary for the public sector organisations that were in charge of this basic infrastructure and which the planners in the past used to consider, in importance next only to defense.

Considering the mess in which the country finds itself now as far as the power availability, its quality and the cost of it to all categories of consumers except of course the rural sector, we in the engineering fraternity have to speak out and say what we want to, on the policy decision taken in a tremendously great hurry for handing over this to the 'sharks', so to say for the profits they are after for themeeelvee and probably for others too who are trying to sell the nation for the temporary benefits not caring for the longterm havoc this policy would do or has already done to the country. Electricity is not a luxury without which the economic activity can develop and survive. But by one thoughtless decision, we made it an item of luxury to every category of consumers. And, as a result, all developmental activities have slowed down effecting the economy of the nation.

The main excuse or justification given for the privatisation policy, for this sector in particular, was that it is capital-intensive and that the resources required for its continued growth were not available. It is true that it is capital-intensive but it is not true that the resources were not available for its sustained growth. The power sector has not been asking for allocations any more than it was hitherto being given. While the outlay for the power sector might appear to be high in absolute terms, this sector's percentage share in the total plan outlay was being reduced deliberately plan after plan irrespective of the consequences of such a reduction on the economy of the country. The diverted resources were being allocated to the less important populistic sectors for vote catching.

Let me refer here briefly to the steps taken for the development of the power sector in the country since independence. In my view, the decision to include, the power sector in the concurrent list of the Constitution was the first mistake. The total available capacity in the country at that time was negligible and the States with their meagre resources were not in a position to handle this key sector effectively. Having done that we enacted the Electiricity (Supply) Act of 1948 with the help of some Johnnies from UK. They drafted it on the basis of the then existing Area Boards in UK having responsibility for generation, transmission and distribution in the area of their jurisdiction. In our case, the States replaced the. Area Boards. Very soon UKfound that generation and transmission should be taken away from the Area Boards and entrusted to a central organisation, leaving only the distribution with the Area Boards. CEGB or Central Electricity Generation Board was the outcome. Weshould have done the same ddcades back.

I have been advocating in many a forum that availablity of electricity in quantum and quality, so essential for the economic well being of a developing country like ours, should never have been allowed to be mismanaged by the individual States with varying degrees of inadequate resources and managerial skills. I have also been suggesting that power stations should be set up at places where it would be cheapest to generate and transmit power to places where it is required at a uniform high-tension tariff, leaving only distribution to be handled by the Electricity Boards. This was not done. However, electricity being a concurrent subject creption of an organisation like the NTPC was advocated for the construction of large pit-head thermal stations and to eliminate the need for the States to indulge in the construction of thermal stations at thoroughly unjustifiable places generating electricity at very uneconomical rates.

This concept of large pit-head thermal stations, for which I can take some credit, worked well. And NTPC succeeded in adding a very substantial percentage of the total generating capacity in the country. But for NTPC, the country would have been in an even greater mess than it is today.

If only the NTPC had been helped by the States by clearing the dues for the supply of energy to the SEBs, NTPC would have been in a position to borrow from the local and international financing institutions to supplement its own resources and to put up a substantial additional generating capacity to get ever the prevailing crisis. What the private sector has failed to do inspite of all the sops given to it, NTPC would have done if it was helped to realise the mounting arrears from the SEBs.

Looking at the mounting arrears and the reluctance of the Centre to force the clearance of the arrears by the States, institutions like World Bank refused to provide the loans to NTPC. Instead, they got the handle to advocate the so-called liberalisation and privatisation policy. No one would object to this policy. But its application to the core sector like the power sector and that too with such an unpardonable hurry is essentially responsible for an almost negligible additional generating capacity we added during the last nine long years instead of 70,000 MW that would have been added in the normal course. The fanfare, with which privatisation in power sector was initiated with road shows outside the country in particular, proved to be a non-starter. '

If we had initated privatisation by asking the NTPC, BHEL and the financing institutions within the country to form a consortium and ask the international financing institutions and the major manufacturers of power plants to join this consortium to set up super thermal power stations or mega projects, we would have succeeded in commissioning atleast 60,000-70,000 MW during the last 8-9 years. Instead, we left this core sector to be meddled with by unscrupulous private sector agencies which cared not for the guaranteed returns but what they could get by inflating the capital costs with the connivance of the suppliers. It is very unfortunate that the States and the Central Government refuse to take cognisance of this.

BHEL which has proved its capacity for manufacturing power plants comparable to the very best in the world and the NTPCfor erecting and running the power stations with very creditable efficiencies should have been in the forefront for providing the required generating capacity in the country. Ignoring the local manufacturing capacity; we have thought it fit to allow all sorts of imports at unjustifiable capital and running costs. Since the country needs to commission about 10,000 MW per year for a number of years to come, the obvious course would have been to discuss with BHEL the maximum number of 500 MW units they could deliver per year during the next 10-15 years and place the orders for the same on condition that the price for the 500 MW units would be atleast 30 per cent less than what they are charging for orders of one or two units. This is possible and I had discussed this with the BHEL a number of times in the past.

The consortium of the type indicated earlier will be in a position to mobilise the financial resources if the orders are of that magnitude. Two or three recognised manufacturers in the world could supplement the requirements of these size units to get the benefit of suppliers' credit. Bulk order for a number of units of the same size and make will bring along with it a number of other benefits lime uniform layouts, standardised civil and structural works, speedy construction, minimum number of spares, ease of operation and maintenance, etc. NTPC should be the principal agency to plan, construct and run the power stations,. keeping in view its capacity to produce power plants upto 600 MW, China is reported to have banned import of power plants of sizes below 600 MW.The stations to be set up should either be at the pitheads or coastal areas with capacities of 2,000-3,000 MW each. These stations should feed the national grid and the grid should supply to the SEBs and other large consumers on the basis of LOCs or Escrow accounts.

As far as hydel generation is concerned, the present methods of investigation and execution have become outmoded. These have to be discarded and· intensive mechanisation will have to be resorted to, if we intend to develop this renewable source of energy and reduce the overall cost of energy to the consumers. Most of the States, which have the hydel potential still to be developed, are not in a position to take up the projects for lack of financial resources. The Centre may have to take up execution of these on the basis of the following, which Iam sure would be welcome to the concerned States:

The Centre should undertake to finance the projects and supervise their execution by the States or entrust the execution to a central agency like the NHPC. Financing could be through international financing agencies.

After completion of the project, Centre should be prepared, to make available to the State for use within the State, the quantum of power the State might need from time to time on cost plus basis. Any surplus energy could be used by the Centre by feeding it into the national grid and selling it to any of the neighbouring States on agreed terms and conditions.

The State concerned will not only be paying for the energy on cost plus basis but also a specified amount every year or an extra rate per unit of energy being used by the State to redeem, over a specified period, the total amount spent by the Centre i~ the execution and operation of the project. After the total amount spent by the Centre is realised, the project should be handed over completely to the State.

Nuclear energy which wasgiven back seat at the instance of the very powerful and wily oil lobby by exaggerating the smallest of accidents and human errors, ought to be the main source of energy in future. With the aid of computers and software available, it is possible to run the nuclear stations with hardly any human interference, thereby eliminating accidents of Three Mile Island and Chernobyl type. The energy cost from the nuclear stations would be no more than the cost from the conventional fossil fuel stations which have to reckon with the rising costs of coal, oil and gas and their transport every year. The targets we have set for our nuclear programme should be raised considerably, reducing the fossil fuel based generation. In this connection, it is very important to note the remarks made by the RClssian President Mr Putin about the cost of nuclear power. He told it to be possible to be produced at one-tlhird of the cost of any other fuel-baeed power.

To ensure that Electricity, which is the basic infrastructure for all developmental activities, is not in short supply and is made available at the cheapest possible cost, the required financial resources should be made available to it at the cheapest possible cost or interest rates. The local financing institutiol1S should set aside for this sector a certain percentage of the total funds they lend and should make them available at very nominal rates. The Government of India, which borrows from financing institutions abroad and foreign governmental and non-governmental agencies at very low rates of interest, should not levy any additional charges for transferring the Same to the power sector. These and various other steps could keep the cost of power at the lowest possible level.

The national grid should be allowed to supply directly to all high-tension consumers, since the industry should not be loaded with the exorbitant rarrlffe, which the SEBs are now demanding to make up for their inefficiencies and the losses on accou nt of more or less free eupply to the ag ricu ltura I sector. The industry cannot be expected to be competitive or survive, if it is subjected to scheduled and unscheduled power outages demanding on the requirements of some other less important consumers.

That the agricultural sector needs subsidy cannot be denied, but this is a national responsibility and the SEBs cannot be allowed to pass on all the losses to other categories of consumers. A decision has to be taken at the national level to levy some tax on all consumers of agricultural products to take care of the subsidy required for supply of electricity to the farmers. A determined effort is also required to be made to see that the electricity is used essentially for drip or sprinkler irrigation and not for paddy. Sugarcane or similar crops requiring large quantities of water. This will help in saving energy and also in conserving ground water resources.

The tariff for the agriculture sector should be made uniform throughout the country based on the energy required for lifting say 1000 gallons of water. This will take care of the widely varying ground water levels. In the lternative, region-wise energy tariffs could be considered based on the prevailing ground water levels. The States should not be allowed to decrease or increase these rates.

By entrusting the national grid with the responsibility of taking power from the super thermal stations, use of the available generating capacity can be maximised and it is possible to even out the deficiencies and surpluses in different areas of the country.

Once the national grid tariff is determined, it would be possible to ask the SEBs and the other power generating agencies already in the field to feed into the grid their surplus or draw from the grid their requirements at this national grid tariff.

What has so far been said is about the ills of privatisation of the power sector and what could be done to tackle this. Now what about the performance of the SEBsf It is their miserable performance that has hastened the privatisation programme. Having had the privilege of serving two of the SEBs in the country and making them the best in many respects, I do have views on prevailing ills of these organisations. While there may be some exceptions, most of the politicians would not like to seethe SEBs headed by persons who may not be willing to say 'NO' to their dictates. The heads are selected not on the strength of their back-bone but on its flexibility. Naturally, what can one expect from the spineless heads who are most of the time busy kowtowing to the dictates of the politicians, irrespective of the impact of this on the organisations they head. It is once again t.lle politicians who are to be blamed for the plight of tr10st of the Boards. The people put in charge have hardly any control over the staff, either in regard to the work they ought to be doing or to the numbers employed. The management hardly controls the staff. It is the staff that dictates to the management. Most of the SEBs can be run with 30 per cent of the staff they have. We seem to have created the SEBs for serving their employees and not the poor consumers, who are being asked to pay heavily, ever so often for the inefficiency of the SEBs and the equally inefficient governments behind them. I do not want to get into the details of the inefficiency that runs riot in many branches of the SEBs, but suffice to say that it is the mismanagement of the SEBs that is responsible for the insistence of institutions like the World Bank for the privatisation of the SEBs. But privatisation is only going to fill the pockets of the investors and not alleviate the plight of the poor consumers. Even without privatisation there are ways and means of serving the consumers better by drastically reducing the manpower, reducing the theft and technical losses of energy, reducing the capital cost of equipment, operation and malntence costs of the entire system, etc. But who is interested? May be consumers, but not those running the SEBs. Having touched some aspects of ailing power sector, one has to write the prescription for the cure. In my view, I would prescribe the following:

- BHEL and NTPC should be the agencies with whatever assistance they can get from within the country and outside with total support from the Government of India for the guarantees.

- Low-interest loans from other governments and financing institutions should be set aside for this core sector.
- Only 2,000-3,000 MWpit-head and coast-based power stations should be considered.
- National grid should concentrate on country-wide transmission system.
- States should.be discouraged from indulging in setting up power stations through PPAs with private parties. They could ask for a share in the mega stations and enter into PPAs with them.
- Urban distributions, for which there would be many takers, could be handed over to the private sector for ensuring better rapport between the suppliers and the consumers which is nowmiserably absent.
- All high-tension consumers should be supplied directly by the national grid. Rural electrification is the responsibility of the entire nation. What the tariff should be forthe rural consumers needs to be decided at the national level and enforced without any modifications.
- The States should organise rural electrification corporations with an apex body supervising the district or mendel-wie« units. Crops like paddy, sugarcane, etc requiring large quantities of water should not be through lift irrigation. To save energy and ground water resources, drip and sprinkler irrigation should be encouraged.
- Discard low-tension distribution in the urban and rural areas and adopt high-tension distrtibution instead to save on the losses and theft of energy.
- Make sure that the SEBs or their new Avatars do not indulge in over staffing or providing employment to all and sundry. They should create employment by sustaining the industrial, agricultural and other sectors through quality of supply at the cheapest and affordable rates.

Risk and Uncertainty in Contemporary Society Role of the Engineering Professional

Prof Ajoy K Ghose

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Engineers, from time immemorial have evinced their capability for great technological feats that have transformed the world around us. As we move into the 21sl century, our expectations have soared to new heights and we are looking for a cascade of innovations that will help enable us to face the challenges of wealth creation and sustainable development. While the leverage of technology can and do effect miracles, environmental responsibility imposes severe constraints as engineers of today and tomorrow have to hone their eco-skills in developing technological solutions that are environmentally compatible as well with acceptable risk. Technological cornucopia, which engineering professionals largely subscribe to, assures us of the expanding potential of innovations for the greater good of mankind. In the midst of such promising vistas, events such as of the Black Tuesday, the 11th of September, 2001, often rudely shatter our dreams; major natural and man-made catastrophes from time to time also make us painfully aware of the risks and uncertainties of the world around us and of the large technological systems that we design with meticulous care using the best of engineering judgment. Like the principle of indeterminism, we have to live with risks and uncertainties, especially the residual risk, despite significant advancements in our insight and understanding of systems, their interactions and even of the 'butterfly effect" of sensitive dependence on initial conditions. In view of the pervasiveness of risk in contemporary society, their quantification and mitigation are issues of concern. Engineers, as the architects sculpting the global landscape, have to address the question: how safe is safe enough!

As a concept, risk gives meaning to things, forces, or circumstances that pose danger to people or to what they value. Predictably, the analysis of risks of various kinds has been at the center of a number of fields of study in science, including social sciences, and technology and the domain for analysis ranges from high finance to transport, and energy production to sports. Ulrich Beck coined the term "risk society" to underscore the fact that in the contemporary world. society is beleaguered by an assortment of risks; there is also a globalization of risk in the sense of intensity (e.g. nuclear holocaust) and in terms of the expanding number of contingent events which affect everyone or at least very large number of people on the planet. As society is taking leave of the past, of traditional ways of doing things and is opening itself up for a problematic future. there is heightened awareness of risk as risk.

Risk analysis is all about predicting events that have not happened, combining the probability of occurrence of an event and the consequences of the event should it occur. Engineers, as the final arbiters of their designed structures, have to depend ultimately on the tool of risk analysis, despite all its imperfections. The probabilistic analysis approach (PRA) surfaces major definitional and interpretational issues of the meaning of probability and of risk andthus far engineers have sought to address the issues of technical risks due largely to equipment and structural failure. There are extensive studies on risk analysis for dam safety, for instance, based on qualitative methods, event trees. Bayesian approaches with probabilistic characterization of judgment. And reliability approaches with probabilistic characterization of parameter uncertainty, all of which look very elegant, but in the final analysis defining the acceptable risk criteria is a judgmental consideration. Uncertainties associated with engineering problems could be divided into' two groups: aleatory (inherent) and epistemic (lack of knowledge) uncertainty. Aleatory uncertainty represents the natural randomness of a property. The variation in the ocean wave height and the variation in the soil property in the horizontal direction are aleatory uncertainties which cannot be obviated. Within the epistemic class of uncertainties, one finds data uncertainty (due to instrumental or human limitations), model uncertainty (due to imperfections of a model) and statistical uncertainty. Quantification of these uncertainties in turn call for reftec tion andengineeringjudgment andaccountingfor uncertainties. Even if the process requires judgment, is by far preferable to ignoring them. Engineers, especially civil engineers, often provide for uncertainty by a strategy of "conservatism". This means that they recommend decisions or actions that leave a wide margin for any errors, if the actual risks turn out to be greater than they predict. It is often arguedthat risk analystsshouldinstead present their best available estimate to decision makers, along with an explicit characterization of its uncertainty.

The commonly used definition of risks, which engineers often use, is R = P(E) × C(E) and risk insights have been derived from careful and extensive considerations of operating experience. Research, and the aggregate results of a PRA. Recent approaches have argued for including a multiplier for some risks so that the consequence term is Cx, where x > 1. Even today, we are hesitant to begin a risk analysis using the now famous triplet of questions. raised by Kaplan and Garrick in their oft quoted paper "On the quantitative definition of risk" published in Risk Analysis (Vol.1.pp.11-28.1981) :

• What can go wrong?
• How, likely is it ?
• What are the consequences?

Perhaps one could more realistically and appropriately use Anticipatory Failure Determination suggested by Kaplan in 2001: "If I wanted to make something go wrong. how could I do it?" Threat analysis resorts to this basic approach, but surely it excludes from its purview the ramming of the World Trade Center by a plane! In fact, a vital but essential missing element is the impact of human actions (deliberate. or simply an error) in all such probabilistic risk analysis approach. This has been forcefully demonstrated in the case of Chernobyl, where the design flaws in the RBMK made the accident possible. but operator errors took the reactor to high danger regime. At Three Mile Island nuclear power plant in 1979, the PORV design did have a control weakness. But the operators not understanding the system led to destruction of the reactor. Even Bhopal and Exxon Valdez are cases in point. Integrating humanfactor analysis into risk assessmentfor plants andfacilities is imperative which engineers sometimes are oblivious of organizational tendencies, such as to disregard warnings about possible dangers often exacerbate risks. This was dramatically highlighted by an analysis of the catastrophe of the US Spacecraft Challenger in 1986 when 7 astronauts lost their lives. A direct cause was a brittle rubber sealing ring which. according the expectations andwarnings of the rocket manufacturer fractured under low temperature conditions. Even one-day before the take-off. the engineers had warned and protested against take-off plans. These were shrugged off and the engineers silenced by a clinching statement: "Take off your engineering hat and put on your management hat"! The take-off was authorized and the catastrophic accident ensued.

There are contentious issues of public acceptance of risk analysis which engineers may parade or tout as the acceptable risk levels are often beyond the comprehension of the lay public. Statistical probability concepts are heavy to digest. For air travel, the risk statistics of persons range from 1×10^{-5} death/year. 3×10^{-4} for road accidents. and to 2×10^{-3} for parachuting figures which are essentially gobbledegook for the layman who tends to have a suspicion of misuse of these figures. A 19th century quote often attributed to Benjamin Disraeli. the then British Prime Minister. captures the public aversion to such figures: "There are three kinds of lies: lies. damn lies and statistics".

It is commonplace to express the risk of any activity by two measures: individual risk and group or societal risk. The first indicates the probability of an individual losing his or her life due to a mishap occurring as a result of that activity while the second applies to a group of persons. Engineers are guided by the prevailing guidelines of different nations on the risk criterion that would be applicable. The Health and Safety Executive in the U.K. for instance. has a shaded scale of criteria from a broadly acceptable region. via a tolerable region to an unacceptable region in which risk cannot be justified. Between the tolerable and unacceptable region. interventions from control measures become imperative. The maximum tolerable risk (TOR)to any member of the general public for an existing large-scale installation is 10^{-5} per year. In the acceptable region, risk should be minimized according to the ALARA (As Low As Reasonably Achievable) or ALARP (As Low As Reasonably Practicable) principles. In most land-use planning problems, for example for the siting of a facility, the problem reduces to the structure posing a threat on one side and targets vulnerable to effects on the other and risk is to be determined as a function of the distance between a target and a threatening object/structure. We could also look at the problem from the other way around where given a target density around the threatening structure, one has to determine the number of potentially damaged targets. In the Netherlands, the Ministry for Housing, Land Use Planning and Environment (VROM) was the first to legislate a criterion as a law. The law passed in 1988 set the tolerability limit for individual risk due to process industry hazards at 10.6 per year which presupposes that the external safety of a chemical plant should be such that the chance of being killed outside the perimeter/fence of a new chemical plant should at maximum have a value of once in a million years. Group risk tolerability limit has been put at 10.3 per year which means that an incident at a plant site with 10 fatalities in the public community outside the plant area may only happen once in 100,000 years and with 100 victims only once in 10 million years.'

With the environmental armagedd on just round the corner, engineers have to be increasingly involved in decision-making in environmental risk issues of urban centers. The litany of environmental problems is long and unending and for an inhabitant of a mega polis like Kolkata or Chennai, where hydra-headed problems that surface range from safety of drinking water (arsenic poisoning?), safety of building from seismic effects, fires and toxic chemical releases from plants and tanneries, overload of environmental contaminants from vehicular emission, to risks of high tides and long-term health risks of lung cancer amongst many others. Characterizing the risks and aggregating the same would hold out a fearsome spectre and engineers may be called upon to mitigate or eliminate some of the problems at least. In sheer desperation and burdened with such onerous responsibility, an engineer may look for a respite and take refuge in a restaurant only to be suddenly reminded of polluted fish, unclean chicken or meat from a polluted abattoir. He has to decide whether to plump for 'unsprayed vegetables' (?) or simply plain boiled rice! This may sound somewhat facetious, but life has certainly become risky and awareness of risk must seep into the action of almost everyone. We should also make a distinction between voluntary and involuntary risks and known risks and the unknown ones. Currently, methodologies are available to optimize measures of risk reduction. In the process industry, a systematic approach dubbed as Layer of Protection Analysis (LOPA) has been developed in which the contributions of independent risk reduction steps are determined to reach a target value of residual risk. One can weigh the costs of the layers against the benefit, including the costs of business interruptions.

Engineering professionals will be increasingly called upon to address the risks and hazards associated with the changing landscape of social and technological systems which are becoming overly complex, be it in engineering design of facilities, or in environmental safety or even in product design. The tools of risk analysis help them to broaden their vision using better spectacles as it were providing an 'assurance exercise' for mapping the hazards and finding the way to go about in mitigating them. The key to improved decisions in the face of uncertainty for the engineering professionals should be the precautionary principle, the broad definition of which is embedded in Principle# 15 of the June, 1992 Declaration of the Rio Conference on Environment and Development:

"In order to protect the environment the precautionary approach shall he widely applied... Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation. "

Even if this surfaces conflicts between moral. ethical and organizational responsibilities, the Code of Ethics of engineers mandates that the responsibility for the safety, health and welfare of the public must be stressed and even considered to be of paramount importance.

The engineering professionals are increasingly making decisions in which they explicitly consider risks and it is their responsibility to un dertake effective risk characterization for translating the best available information about a risk into languages that could be understood by the nonspecialists. Coping with a risk situation requires a broad understanding of the relevant losses. harms and impacts or consequences to the affected people at risk. which is often multi-dimensional. The success of risk characterization depends critically on systematic analysis that is appropriate to the problem; this in turn should lead to better risk decisions.

In the welter of risks and uncertainties that confront the contemporary society. the elusive goals of sustainable development call for a new mindset of engineering 'professionals who have to evaluate risks of their actions as they build bridges and high-rises. dams and exceptional structures; the engineers can ill afford to contribute to large ecological footprints of high risks. There are wide-ranging debates and controversies on global warming from fossil fuels of catastrophic accidents from nuclear and large hydropower plants of high-level radioactive disposal which are enmeshed in complex technical, social, ethical and political issues. The engineer as a professional must have a healthy agnosticism with a sense of limits of one's own competence prepared to accept the responsibility of management of risk for all his actions and creations.

While the Nidhubhusan Memorial Lecturer is expected to dwell on a subject related to science, philosophy and religion. I have traversed an area which is transdisciplinary, being on the periphery of science and philosophy. In the uncertain world of today, we live in the midst of many sankats or difficulties. Some of these are dharma ssnksts, the moral 'dilemmas of designing risk-free complex technological systems. Much is being demanded today from the engineer of all breeds; he has to be more global, more learning-oriented, more environmentally-focussed, more team driven, more productive and of course more competent for decisions under uncertainty and risks. We must clearly know and realize that with all our efforts for risk minimization, we work with the inexactitude of probabilities!

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Leading to Win the Corporate Olympiad

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It is indeed a great honour and privilege to deliver the Nidhu Bhushan memorial lecture to this August audience today. In fact outstanding people like Late Shri Nidhu Bhushan inspire us to work with determination to serve society. He has been a firm believer in fundamental self-discipline as the route to face life successfully. His capacity to serve society without caring for name and fame is a shining example for all.

I have specially chosen the topic "Leading to Win the Corporate Olympiad" as the theme for today's presentation. It has been my dream to see India as a strong player on the world stage given our'many talents and skills. But I am equally convinced that although India can do it, its worth examining the fact that even to survive this race one has to be an excellent performer with strong winning mindset.

"We are now living through the greatest wave of change on the planet since the enlightenment of the Industrial Revolution. This is a moment of greater and deeper change than any previous time, because no previous revolution was global in scale or as compressed in time. The acceleration of change and the spatial scope of the change ..... mark this moment as different from previous moment .... "(Alvin Toffler).

Toffler is not alone in his dramatic assessment of the imminent scenario. The everyday lives of people across the globe have been irrevocably touched by mega shifts occurring at multiple levels — the technological, social, political and economic. The awe inspiring strides being made in information and communication technology, robotics, nano-technology, life sciences and so on promise to bring further change – sometimes disruptively- in the lives of human beings, to a level vastly different from the 20th century construct of living and working. Developments in communication technology are totally transforming the business paradigm. Cross-cultural encounters are ultimately creating a global culture. The shift to the new millennium is thus a quantum shift demanding a different mode of thinking, living and leading.

Increasingly, India is becoming a part of the global economy. With the business scenario turning into a corporate Olympiad, Indian companies have to trim their size, get more focused, and efficient in order to survive in the face of competition. The fundamental compulsions faced by organisations call for a transformation in the mindset and perspective and in the approach to business and people. Before examining the nature and type of transformation needed, there is a need to assess the dimensions of the emerging business scenario in greater depth.

In this presentation today I will focus on:

• Delineating the context and the scenario in which organisations will have to operate in the 21st century;
• Analyzing the organizational strategies and actions required to cope with the challenges; and
• Examining the required winning leadership styles. In the 21st century we are already experiencing the impact of three phenomena ... Borderless world. Diversity, and Knowledge Power.

All the three are posing large scale challenges to the corporate world and culminating in Olympian competition.

I will now take up each one and discuss in detail.

Borderless World

Developments in IT have revolutionized the speed and means by which both money and information flow. The power of networks in making information available across the globe, across the country, across companies, across employees and across customers has totally changed the ground realities. With the ascent of the market economy model worldwide, more and more countries and markets are opening up and thus a global economy is unfolding.

The growing interdependence of the world economy is brought out very sharply through the cascading impact of one crisis ridden economy on the others. The slowdown of the Japanese economy some years ago which had its impact on the South East, also affected one fifth of the entire world economy.

Today regional blocks like ASEAN, EU, NAFrA, APEC are gaining prominence and influencing each other. It is not nations, but specific regions and locations which are showing robust growth, through their close networks as predicted by Ohmae.

In the realm of trade, prices of commodities and currencies are set by patterns of supply, demand and speculation that operate world-wide. Finance and insurance operate through global markets and world's major stock-markets are all meshed together into one operating system. The borderless ness is evident in the way various aspects of work get done in different parts of the world. With the advent of tele-working, activities like on-line services and software development for many US companies; medical transcription work (electronic and care technology) for American doctors, and reservation and ticketing for some European airline companies, are now being done in India. Ship repairs are moving to India. Drug companies are planning to transfer their R&D activity to'India to take advantage of the cheap skills. The borderlesness in business is also reflected in the launch of products — companies like Gillette, Microsoft and P and G launch their latest products simultaneously from multiple centres world-wide.

Not only are political and geographical borders being rendered irrelevant, the boundaries of organisations are also getting increasingly porous. Shell Oil is the largest seller of packed sausages in the Scandinavian countries where it has a large chain of gas stations. The GE slogan of the boundary less organisation vividly describes the form of the organisation in the emerging scenario, with organisations. Out sourcing all except their core activities. Today vendors and associates are co-partners in business. Companies like Intel and Powersoft probably have thousands of people working for them through partnerships without being directly employees. Mega corporations like ABB straddle the globe with 1,200 companies spread allover. Visa International, the credit card company, spreads across like an invisible financial nervous system ensuring smooth flow of credit across the world. Organisations are redrawing their boundaries in such a way that they are both competitors and collaborators in various markets. AT and T and Motorola, Philips and Sony, Microsoft and Compaq are all competing as well as collaborating in different segments of the world market.

The cross-cultural, cross-border mingling has resulted in the creation of a new class of people — global citizens with global attitudes, tastes and networks. Since it unleashes multiple variables, the borderless world precludes immense complexity — complexity in the environment. In Interorganizational relationships, in modes of conducting business and in socio-cultural diversity.

In India, the borderless world is shaking the roots of business. While some companies are feeling the excitement and facing up to the challenges, the demand for a tilted playing field indicates the anxiety among many Indian business leaders about competition. Increasingly, the mantra of the global economy is performance and competition. The strides being made by Indian industry in the IT and pharma segment and lately in automotives, ought to give Indian industry a huge dose of confidence in the ability to take on the competition using multiple business strategies.

Diversity

While the borderless world is creating global citizens on the one side, it is also threatening the identities of people. Worldwide there is a resurgence of religious fervour, emergence of regional blocks and a renewed ethnic consciousness. These are being used by people as instruments to establish and build identity. The 9/11 incident and the subsequent fundamentalist acts of terror in different parts of the world are indicative of the imminent power struggle in shaping a new world order.

The phenomenon of diversity, challenges the skills of people while negotiating and doing business across cultures. Enron, McDonalds and Cargill Seeds had to face intense pressure from various lobbying groups in India. In recent months there have been protests across Europe against genetically modified food which the US is trying to export. The protests at the Seattle round of the WTO negotiations (and each one of the subsequent WTO meetings therafter), threw up very sharply the differences between those who push for the agenda of business vis-a-vis those making a case for development. The challenge for business leaders is to carry both the agendas without sacrificing one for the other. Diversity is also prominent within organisations. Organisations in various parts of the world are grappling with multi-ethnic and multi-gender workforces. The multiple perspectives and approaches to decision making and problem saving, the attitudes to work, as well as the concept of time, are some of the major challenges to be handled while managing diverse people.

Yet another important facet of diversity is the one emerging from the left vs right brain dominance and the Yin-Yang polarity in the approach of people to business. These stand out most starkly when the oriental and occidental cultures collide. The differences in value systems and philosophies of life colour the perceptions, attitudes and behaviour of people while dealing with each other. It influences the way in which people approach problems, their prioritization and their methods of problem solving. Diversity would also be more pronounced across gender and with more and more women joining the work force, and this phenomenon will pose challenges for effective management.

Knowledge Power

You will all agree with me that the evolution and material advancement of human society has been based on knowledge power. This has played a critical role whether in ensuring increased human longevity, safety and comfort, prospecting and utilization of natural resources, facilitating faster travel and communication or changing gender equations. Increasingly, a larger percent of the cost of many products lies in the knowledge component. Many decades ago Peter Drucker had predicted that the cost of materials in a product would become a small percent of the total product cost. The rest of the product cost is from the R&D efforts which were put into the creation of the product. Information has become the source of a large percentage (3/4) of the value added cost in manufacturing Research and development has created entirely new industrial sectors — in biotechnology polymers plastics, software, semiconductor chips and so on. Clearly then, knowledge power is at the heart of competing effectively. To be winners and leaders in 21st century, companies will have to assiduously pursue knowledge.

Olympian Competition

The emergence of a borderless world, increased diversity, and the pre-eminence of knowledge power has increased the complexity of the business environment and has given rise to Olympian competition. The era of stable and steady organisations is long over and survival in the Olympian era hinges on being hard nosed and fleet footed. The curse of Sisyphus is an all pervasive phenomenon for business organisations, whether it is the Fortune 500 list or the list of India's leading companies. Those who did not change at the required time and speed simply fell off the lists. In the West, giants like GM, US Steel and Pan were rendered Lilliputian. Likewise on the Indian business scenario, the Shrirams Walchands and Mafatlals have lost their former stellar positions.

Companies have to change gears appropriately in order to survive. If the response is slow they are overtaken. For example, the Indian luggage Industry did shift from moulded luggage to soft luggage. However, by the time they made the shift, the market had been taken over by players from Korea and Taiwan.

The phenomenon of competition and the complex market dynamics have thrown up immense paradoxes. The classic example is that of leading American Companies like IBM DEC, GM, Ford, Sears, United Airlines and K Mart, who found that their profitability was not keeping up with their superstar status in terms of market share. On the' contrary, going against contemporary business mindset has seen significant growth in the profitability of companies like GE and Coca-Cola operating in low or no growth industries. Thus companies trapped in the old mindset collapse while those with the right mindset are able to successfully handle the very same paradoxes.

The battle for the customer mind share is growing more and more intense. The case of the watch industry is very instructive in this regard. In the 1970s, Swiss watches ruled the world, on the basis of superior quality. In the 1980s, Seiko of Japan got an entry into the world markets by introducing a new product concept - the digital watch. This product captured the minds and markets of the world, pulling the Swiss industry down into a severe crisis. By the late 1980s under Hayek, SMH brought out the 'Swatch' — a watch with an attitude, which helped the Swiss regain the market share substantially. In the 1999 watch show held at Basel, Seiko displayed hi-tech watches for the mid-range segment — the Seiko Thermic — the world's first watch that harnesses temperature differences to generate energy. In response the Swatch is now being offered with features like net connectivity. This Ping-Pong game of competition will continue till either partner runs out of steam or a third contender emerges to challenge the present incumbent.

The one overwhelming factor which has changed the rules of the game, is the Internet. Merrill Lynch, the world's largest brokerage firm, tried to hold out against going online by improving on many other fronts to woo the customer, and still found that business was not picking up. Then they realised that they could not avoid the inevitable migration of customers to the net and decided to provide an on-line brokerage service. The farreaching power of the Internet is changing the managerial practices in organisations - for example on line buying and selling, business to business transactions, as well as free availability of every kind of information on the net. Costs get slashed with companies shifting to networked transactions.

Organisational Strategies and Practices

What are the organisational strategies and practices that must be evolved to effectively manage paradigm'shifts in organisations for leading in the 21st Century? The four important strategies which I W04ld like to suggest are:

- Global Vision
- Secularization

• Wisdomization
• Metamorphization

Global Vision

Organisations with global dreams have to build global mind frames – a broad perspective and way of working, in order to align themselves with emerging imperatives. This is just the opposite of the earlier unicentric, head quarter dictated perspectives that characterised the erstwhile multidivisional and multi-location organisations.

Companies like ABB, GE, Nestle, Coca Cola, Gillette, Singapore Airlines, KLM are today successful global players because of their perspective. They bring global strengths in to products and services and match them with customer requirements. Global perspective also refers to the ability of a company to hold wide awareness created by inputs from all over the world, in a common global information and experience pool and use it for managing business. Information networks have been created by many companies which give the company the information (what competitors are doing, bench marking, best practices and so on) as well as experiences of company employees scattered all over the world. Such a perspective should also permeate the thinking of those on the shop floor, who actually make the end products, thus enabling the company to meet the exacting specifications needed to flourish in global markets.

However, even as companies are globalizing, there is a strong feeling that there are not enough people available with global vision. Gregerson's study showed that a majority of senior executives (Europe, North America and Asia) felt that there are fewer global leaders than needed and that by and large, global leaders do not have the needed capability. This accentuates the urgent need to groom and train people to. build global mind frames. This can be developed through exposure to the 'target' cultures and countries. For the longer term, business schools can provide cross-cultural awareness, through visits and exchange programmes, compulsory papers on cross-cultural issues, providing a broad liberal arts orientation, inviting faculty from other cultures and countries and so on. The move among business schools from the US, Canada and the UK to have tie-ups with universities in different parts of the world, reflects the winds of globalization sweeping the domain of education.

Global companies are striving to create global vision by inducting leaders with multiple backgrounds and knowledge. As the CEO of GE commented, "The Jack Welch of the future cannot be like me. I spent my entire career in the US. The next head of GE will be somebody who spent time in Bombay, in Hong Kong, in Buenos Aires. "Successful global players are characterized by multi ethnic and multiracial human resource orientation. Gillette ensures cross-cultural sensitivity and orientation by rotating its people. Thus half of the company's expatriate employees have worked in three countries and are on their fourth country assignment.

A global perspective thus means looking at the given situation using the global context as the canvas on which there is an interplay of the local issues. For example, ABB under Percy Barnevik had developed a business design consisting of a corporate head office and highly decentralised units in host nations. These units operated as profit centres.

Several global players like Ford, LG Electronics, Coke, and Electrolux are bringing a strong local orientation in their products in India without sacrificing their global strengths and USP. Ford has announced that its next car (Ikon) is designed exclusively for India. LG Electronics is using Indian names (eg Sampoorna) for TV sets. Coke redesigned its distribution crates and trucks for smoother travel on Indian roads. Electrolux is working on a fridge to keep cooked food fresh, to give chilled drinking water and withstand long power cuts.

Organisations need to display concern and commitment to local issues as well. Companies that have tried to do this - for example sponsorship of cricket matches by Pepsi or Coke, have increased their acceptance in the public consciousness in India.

However, such efforts will succeed in the long run when combined with a major attitudinal change within the company. Respect and acceptance of other cultures and sensitivity to the context are thus important characteristics of successful global managers.

Secularization

Let me now move on to Secularization. The diversity of both the business environment and the organisation can be effectively managed through a secular approach characterised by valuing of the productive individual (one who helps the organisation create and add value) and the productive idea, irrespective, of where they originate. There is a need to introduce a zone of convergence characterized by values of excellent performance and concern for humanity. These are two values which are intrinsically valued by many cultures the world over. Creation of such a zone of convergence amidst diversity sets the tone for organizational conduct.

A second focus area is to develop a clearly defined value system around which the organizational focus can be built. Such a value system typically focuses on how people are treated in the organisation. At Kao Corporation, a belief in human equality and using technology to develop products that would be useful to society and improve the lives of ordinary people has also been at the centre of Maruta 's value system. Such values carry conviction and gain acceptance through consistent actions and styles of the senior management.

In order to promote a secular organisational culture companies have to:

• Evolve a set of core values focussing on ideas, contribution, innovation, excellence, customer orientation, human dignity, a questioning culture, participation, empowerment and so on.

• Carve out a vision that could be holistic, global and humanistic, having universal appeal.

Wisdomisation

According to Gene Meieran, leader of Intel's knowledge management programme, "Wisdom allows us to make decisions about the future, whereas knowledge concerns decisions about the present...relating, understanding and judging from expertise and experience you come up with wisdom".

Organisations typically deal with data, information and knowledge.: Wisdom, however is not disseminated in a broader fashion in the organisation - it lies in isolated pools. Wisdomization refers to the process of constantly integrating knowledge with action and utilizing it to take effective action and build competitive edge. In the absence of such integration knowledge remains sterile and arid thus making scant impact on the constant evolution of the organizational processes, styles, systems and the collective organizational consciousness. The creation of the knowledge society and the rise of the specialist - Drucker's knowledge worker - clearly points in the direction of the need for business to effectively manage knowledge and convert it to wisdom in order to keep pace. As more and more organisations become technologically sophisticated and IT empowered data and information availability from both within and outside the organisation are becoming a way of life. Companies like Benetton (Italy), GE (USA), Netscape (USA) and National Bicycle Industrial Company (Japan), routinely get information about customer preferences, likes and dislikes and use this information in manufacturing products to suit customer requirements and also to customise products.

Companies have also moved beyond data and information bases, to knowledge bases, which contain the additional dimension of personal experience and learning. Airfreight Couriers has developed a knowledge centre into which is fed the understanding of trucking routes which a few experts in the company have come up with Consulting companies like Ernst and Young and Anderson Consulting have published best practices in on-line knowledge containers for the benefit of other colleagues. Creation of knowledge centres in companies like HLL (India), Wipro, Infosys indicates the emerging knowledge management focus in Indian companies. Networks are extremely useful when the company has offices, associates, partners all over the world. However, while the Internet provides access and enables pooling together of the data almost instantaneously, actually bringing about wisdomisation is a human process.

Important initiatives for wisdomising the organisation have been taken by leaders like Jack Welch, Roger Enrico and Andy Grove in their companies. An three are known to coach and groom their employees. Such teacher-leaders have successfully converted knowledge into wisdom for action, by providing their executiveswith the distilled essence of their experiences, heightening intuition, through a mind frame going beyond data and knowledge. Their inclusive orientation has helped to instil this wisdom into the collective organisational psyche.

Wisdomisation is not something, which can happen only from the top in the era of intellectual capital and niche expertise, organisations which can tap specialist knowledge and create systems by which it is collected into a bigger pool for the benefit of and utilisation by more people in the organisation, will lead in knowledge creation and conversion of the same into wisdom. Wisdomisation of the organisation especially around cutting edge research and know-how becomes especially important in R&D setups where it can help increase the general level and orientation of the collective mind of the unit. This will provide a unique edge to the company by speeding up the pace at which the organisation can move to the next level of .innovation. Business schools and other educational institutions can also benefit from such an approach. It will help them to stay relevant and respond to the needs of the industry.

In my view, organisations have to inculcate the following to promote wisdomization : .

• Teaching Culture: Converting managers into 'action professors', converting experience into concepts and then teaching this to others so that the action is taken in the new perspective, is a major task for organisations. When McKinsey decided to energise the training of their associates, they got their partners to double up as professors.

• Recognition: Many companies have used this as a means to simulate sharing, learning and innovation. Ernst and Young rewards and recognizes employees who spend time helping each other and contribute to the corporate database-This is also one of the criteria used in performance reviews.

• Learning: Organisations are now becoming major learning centres where people can acquire and constantly upgrade their knowledge. GE, Motorola and Intel are examples of organisations that promote learning through their own courses; Buckman Labs (USA) promotes learning through distance learning courses.

• Tolerance of Failure: To encourage learning and converting that learning into wisdom, organisations must display tolerance of failure. Frank Douglas, former head of research at Ciba Geigy dealt with failure on a major drug research effort by encouraging the team to convert the findings into articles and get them published. Internally. the benefit of learning from this failure helped pre-empt problems in subsequent research programmes. The contribution was intangible but very valuable and is a powerful example of the benefits of wisdomisation for the R&D function.

Unfortunately, one of the major shortcomings of most Indian organisations is their inability to integrate thought and action. In fact the hierarchical orientation in Indian organisations has resulted in a clear-cut division between the thinkers and the doers. Hence, it is a major challenge for Indian organisations to initiate the wisdomisation process. In order to create the required mindset for the integration of thought and action, the school curricula must focus not only on knowledge creation, but also on imparting skills and attitude to convert knowledge into action. In other words, the 'what' and the 'how' must go together.

Metamorphisation

This is a process by which an organisation transforms itself fundamentally from time to time to cope with the challenges to its survival and growth. When a proactive change is induced to deal with anticipated shifts in the environment, the organisation comes out a winner. In contrast, organisations which change only under environmental pressures, lose out and become laggards. In highly competitive industry segments like IT, Grovian paranoia is essential for survival.

Following are some among the key approaches of metamorphosing organisations.

They begin with the end mind : customerization is the base from which they define everything that they do. With competition becoming a constant factor in almost all industries, the customer has many more options to choose from. Organisations will therefore have to go back to the basic raison d'etre of existence of ail business - the customer. Seeking to find ways by which ABB could contribute to the success of leading Canadian companies, regardless of whether they were ABB customers, Paul Kefalas CEO of ABB Canada, sent experts from across its units to work with representatives of the willing companies. The outcome was a dramatic boost in results leading to alliances with a dozen big companies by 1995 and a clear operationalisation of ABB Canada's corporate strategy - "ABB contributes to the success of its customers by developing mutually beneficial long-term relationship". Maruta, chief of Kao Company brought out this spirit very lucidly when he said, "As a company, we do not spend our time chasing after our rivals. Rather by mastering our knowledge, wisdom and ingenuity to understand how to supply the customer with surprise products, we free ourselves of the need to care about the moves of our competitors". Kao Company started small and went on to become a 7 billion Japanese corporation, the largest consumers packaged goods company in Japan.

The move by many companies (G.E, Xerox, AT & T, Enron) to provide client organisations with total solutions, is a powerful business strategy in the race to provide greater service to the customer.

They practice creative destruction: they embrace death, metaphorically speaking. They create their future destination and destiny, rather than becoming a slave to their past history. In the present scenario of dynamic dis-equlibrium, companies have to metamorphose their orientation and strategies as many times as the business paradigm shifts. What distinguishes the best of world-class companies from the rest is their ceaseless effort to live in disequilibrium and exceed their own benchmarks. Under Jack Welch, GE has shifted its approach thrice over the years. Be "number 1 or number 2" was the first strategy, followed by "workout" and finally the "total solutions" approach. Every time, the challenge has been aimed at responding to customer needs in a way that provides a distinct edge as compared to the competitor.

They are paranoid and constantly try to retain their position by moving faster than the competitor: They build self as the benchmark and compete against that through constantly questioning and re-examining their own styles and strategies. Intel and Andrew Grove, symbolise the paranoid business mindset and the phenomenal results which ensue. Grove started with the strategy of actually selling to the customer unlike others in the industry. Another Grovian example to stay ahead of the competition was the parallel processing of three different generations of chips. Instead of beginning a development every few years, Intel initiated a development effort every year. This gave it the kind of lead in the market where Intel could charge a high price on its microprocessor, capitalising on the 'early bird' advantage and selling at a premium. Once the competition caught up, Intel moved on to release its next new microprocessor and this way stayed ahead of the rest of the players. Another giant corporation, Microsoft has been periodically reinventing itself. At the same time such companies have clarity and vision. They have focussed both on consolidation as well as moving the organisation to the next level of the growth curve.

They practice flexibility : They are not bogged down by the approach which they may have frozen at an earlier point time. High growth companies (3m, MS, SW Airlines, Intel) continue to push boundaries and grow because flexibility is their quintessential characteristic. They don't bind themselves down with elaborate and rigid strategy and planning. According to Herb Kelleher, CEO South West Airlines, "Our strategic planning is an effort to establish flexible goals and guideposts, not detailed action steps". Microsoft does not appear to do advance planning but reconfigures strategy as it goes along .

• An important way in which companies meet the challenges of competition is by creating technologically driven approaches to meet customer requirements. Those in the lead pay close attention to technology and set the pace through their R & D efforts. The race in the cell phone market to provide superior product features is an example. Nokia, the Swedish company plans to put the Internet in every pocket. The Bangalore based Graycelliaunched a unique customer service: the exchange of web and e-rnail messages between the Internet, pager and cell phone users. Indian companies like Ranbaxy are now spending 6% of sales on R & D to ensure a place for themselves in the global Olympian race.

• More and more companies are using the benefits of the net for ecommerce and the results have been exciting for both the consumer and the company. Companies which have moved to net transaction – Schwab (online brokerage), Intel, IBM, Siemens and NEC (selling on the net), have provided greater ease and speed to the customer. The positive impact of e-trade on the speed of business is evident from the fact that in Singapore, port transactions were reduced from 3 days to 15 minuteslby Intelligent application of electronic data exchange. In India ICICI and HDFC banks are at the forefront of the Internet led banking revolution. HDFC bank has pioneered the use of mobile phones for banking convenience of the customers in Bombay and New Delhi.

• Metamorphosing organisations are highly aware and conscious of themselves and possess a strong sense of identity which helps them to continue to grow. Yet they are well aware that their own growth depends upon the development and proliferation of users. They seek to 'grow' the industry. Intel has chosen the route of encouraging start-ups working on Internet based activities by providing them the venture capital. The approach of Microsoft has been highly strategic from the beginning. It has entrenched itself as the standard in the' minds of the customer. By encouraging software developers to use windows as the platform, it ensured proliferation in use of windows. In contrast, although Macintosh and Linus are good OS, their limited use has discouraged software developers from using them. In the context of the shifting scenario (from the PC age to the Information Age) however, Microsoft is being seen as a laggard in providing the technology needed for businesses to handle Internet transactions. The business opportunities abounding in the Internet age are being seized by companies like IBM, Netscape, Oracle and a multitude of new companies, much faster than Microsoft, in an era when speed is everything.

• Yet another powerful means of metamorphisation is through coevolution. Co-evolution is the process of helping other companies evolve by educating, working together, sharing resources and expertise. It is a powerful way of achieving development and growth and also an important route to deal with complex aspects where convergence is poised to take place across technologies. Thus companies have gone in for a spate of collaborations and alliances in an effort to co-evolve themselves and also develop the industry. Kodak and Intel have together formed an alliance for three years, jointly developing products. Microsoft is working with more than twenty partners like Canada's Northern Telecom, France's Alcatel, USA's Compaq, Germany's Siemens AG and Japan's Toshiba Corporation. A collaborative approach has been suggested by Knudson (principal, Global Systems Technologies) to accelerate the growth of the Indian Software Industry.

On the Indian scenario companies like ICICI, HLL, Wipro are seeking to metamorphose themselves to become part of the world class league of companies. For example, HLL is seeking to create an organisation that does continuous lateral thinking and innovation rather than being system driven in an attempt to prepare itself for the new millennium. They however, need to build the strength to be able to do this as many times as the environment demands.

My dear friends, I have shared with you the road map as Isee it, to make Indian organizations into winners in the Corporate Olympiad. If all of us collectively decide to take this up as a mission, I am very confident that we can build many Olympic champions - to make India a leading economic powerhouse in the 21st century.

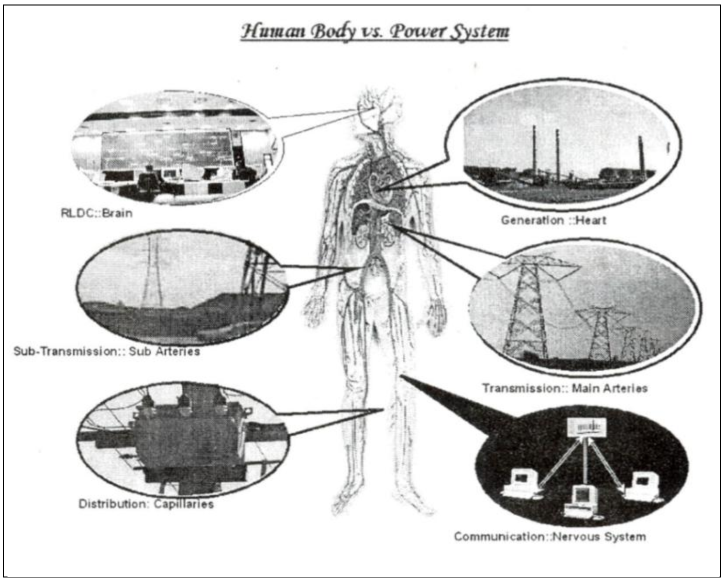
Thank you very much for your kind attention.

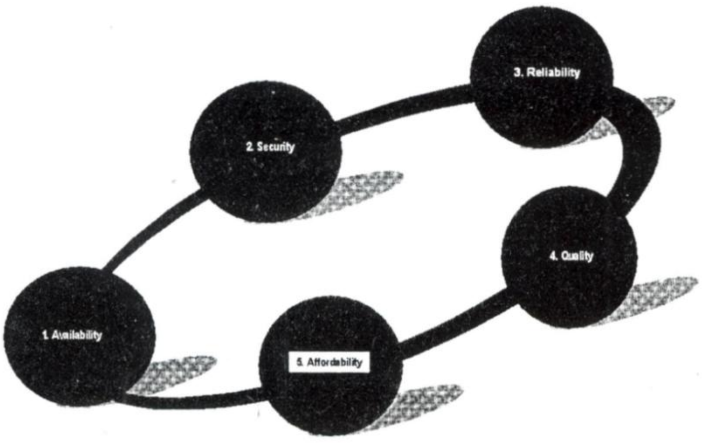
JAIHIND

Integrated Power Sector Development for Long Term Sustainability

Shri R P Singh

Chairman & Managing Director
Power Grid Corporation of India Limited





Availability of Power

Through :

a) Generation Addition

b) Energy Conservation

Present Status

Installed Capacity - 123,450 MW

Thermal	Hydro	Nuclear	Others
67%	26%	2.5%	4.5%

Present Peak Demand – 89,000 MW

Peak Availability – 81,000 MW

Energy Deficit – 7-8%, Peak Shortage – 11%

Growth of Demand - 8-9%, capacity addition required

India's Energy Requirement

Forecasts for demand (as per 16th Electric Power Survey)

	Peak Demand) (MW)	Energy Requirement (BU)
End of 10th Plan (2006 – 07)	1,15,705	720
End of 11th Plan (2011 – 12)	1,57,107	975
End of 12th Plan (2016 – 17)	2,12,725	1320

India's available energy resources

Coal	246 billion tonnes (87% non coking gr.)
Hydro	84,000 MW at 60% PLF
Crude Oil	728 million tonnes
Natural gas	660 billion Cu-m
Lignite	5,060 million tonnes
Renewables - Biomass - Wind, solar etc.	 6000 MWe 20,000 MWe
Uranium	78,000 tonnes
Thorium	5,18,000 tonnes – can sustain several hundred years requirement

Generation Addition

Diversified use of resources in Indian Power Sector

* Coal
* Hydro
* Nuclear Energy
* Natural Gas
* Liquid Fuel
* Agricultural & domestic waste
* Solar & Wind power

Right generation mix to be adopted

Generation Addition

Coal and hydro : two major resources

Between the two, coal has wider acceptability due to

Low initial investment

Shorter gestation period

Availability of Coal

Long term sustenance questionable

Exhaustive resource

Not Environment friendly

Disposal of ash : due to high ash content

Increased dependence on imported fuel (about 100 MT by 2011-12)

Generation Addition

Hydro Power : Limitations

Huge funds requirement

Land Acquisition, Resettlement & Rehabilitation etc.

Longer Gestation Period

Young Mountains

Setting up an Authority

Focus on development of hydro projects

Minister level person as the Chairman

MOS level as members

Preferably, the Authority may be apolitical else cutting across political boundaries

Nuclear Generation

Environment Friendly

Compact source

Technologically proven

Economically Viable

GENERATION ADDITION ENVISAGED

figures in MW

Year	Hydro	Thermal	Nuclear	Others	Total
End of 9th Plan	26,269	74,550	2,720	1,628	105,167
End of 10th Plan	37,184	101,035	5240	3000	146,459
End of 11th Plan	59,604	134, 571	10180	7600	211,955

Source : National Electricity Plan of CEA

Energy Potential from Non Conventional Energy Sources

RESOURCE/SYSTEM	POTENTIAL	ACHIEVEMENT (AS ON 31.03.2005)
WIND POWER	45000 MW	3595.00 MW
SMALL HYDRO(up to 25 MW)	15000MW	1705.00 MW
BIOMASS POWER	19500 MW	
Biomass based Power	----	749.53 MW
Biomass Gasifiers	----	66.23 MW
ENERGY RECOVERY FROM URBAN & INDUSTRIAL WASTE	2700 MW	41.98 MW
SOLAR PHOTOVOLTAIC POWER	20MW PER SQ.KM	2.64 MW
TOTAL	82,200MW	6160.38 MW

Xth & XIth Plan Programme of 3000 MW & 7600 MW

Approach for Generation Addition

Hydro resources to be harnessed earnestly

Nuclear to play major role - Three stage development

- Pressurized Heavy Water Reactors (PHWRs) using natural Uranium in first stage
- \Fast Breeder Reactors (FBRs) using Plutonium based fuel in second stage
- Advanced Nuclear Power Systems utilizing Thorium in final stage

Long term sustenance with renewable sources

6. Energy Conservation

Shall mitigate the gap between demand and supply as well as reduce environmental emissions

Saving potential

- 15,000 MW at end of IX plan
- additional 5000 MW at end of X plan
- additional 4000 MW at end of XI plan

Regulatory & promotional roles

Systematic & urgent action plan to make it a national movement

Security & Reliability

a) Wire Network

Transmission & Distribution Networks

b) Communication Network

Load Dispatch & Communication facilities

a) Wire Network

Investment in T&D Sector

Electricity outlook 2004 published by International Energy Association (IEA)

Investment outlook in Energy Sector

About US $ 16 Trillion investment in Energy from 2003-30 or US $ 568 billion / year

US $ 10 Trillion in Power Sector (60%)

US $ 5.5 Trillion in T&D

In India investment in T&D is only 30%

Huge investment required

Investment in Transmission : US $ 17-18 Billion

Present Status

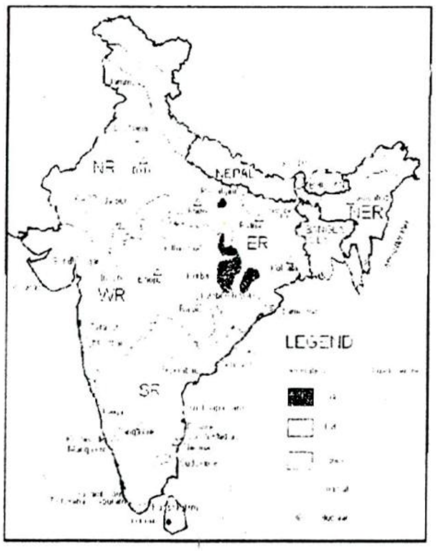
Priority to generation

50:50 investment in generation and T&D recommended, however, at present 72:28

Popular belief that T&D will come up if enough generation is established

Similar thought process in developed and developing countries

Energy Resource Map



- Hydro potential in NER and upper part of NR
- Coal reserves mainly in ER
- For optimal utilization of resources – strong National Grid

Challenges in Transmission

Right of Way

R&R

Conservation of forests, flora & fauna

Integrated Transmission System planning and selection of proper technology

Solution

HVDC & EHVAC Transmission System upto 800 kV with multi Ckts

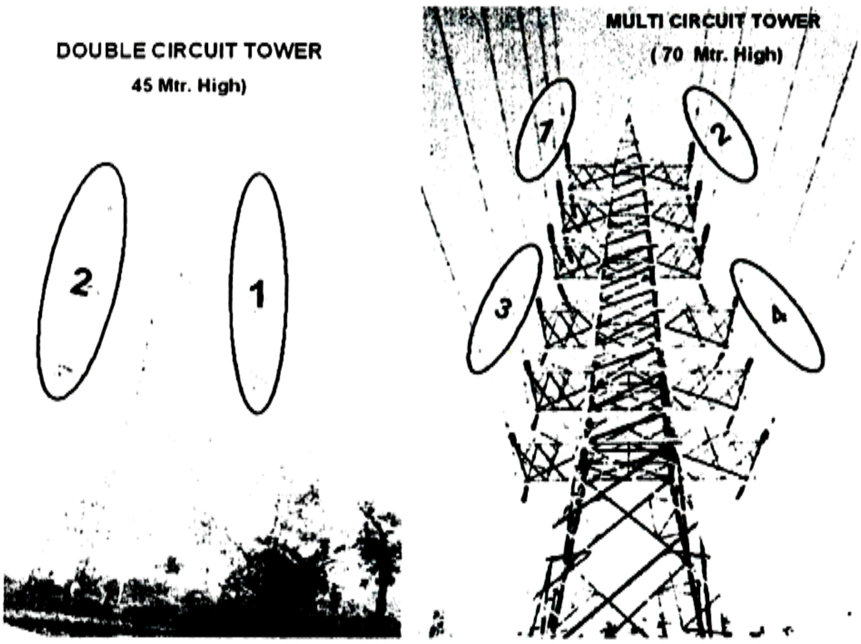
Use of fixed & variable Series Compensator (FACTS)

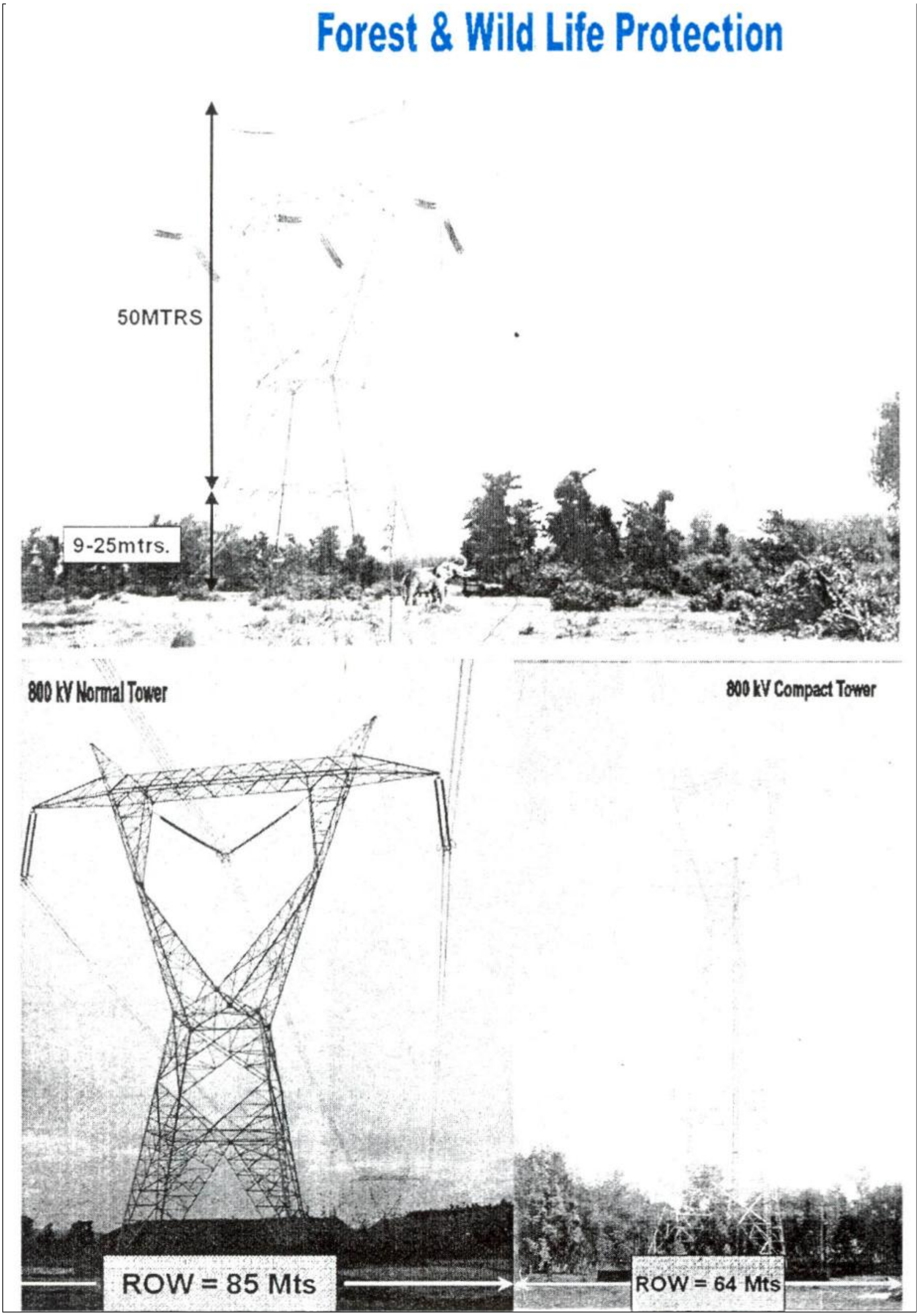
Extra High Towers to avoid deforestation and protection of wild life

Compact Towers to reduce Right Of Way

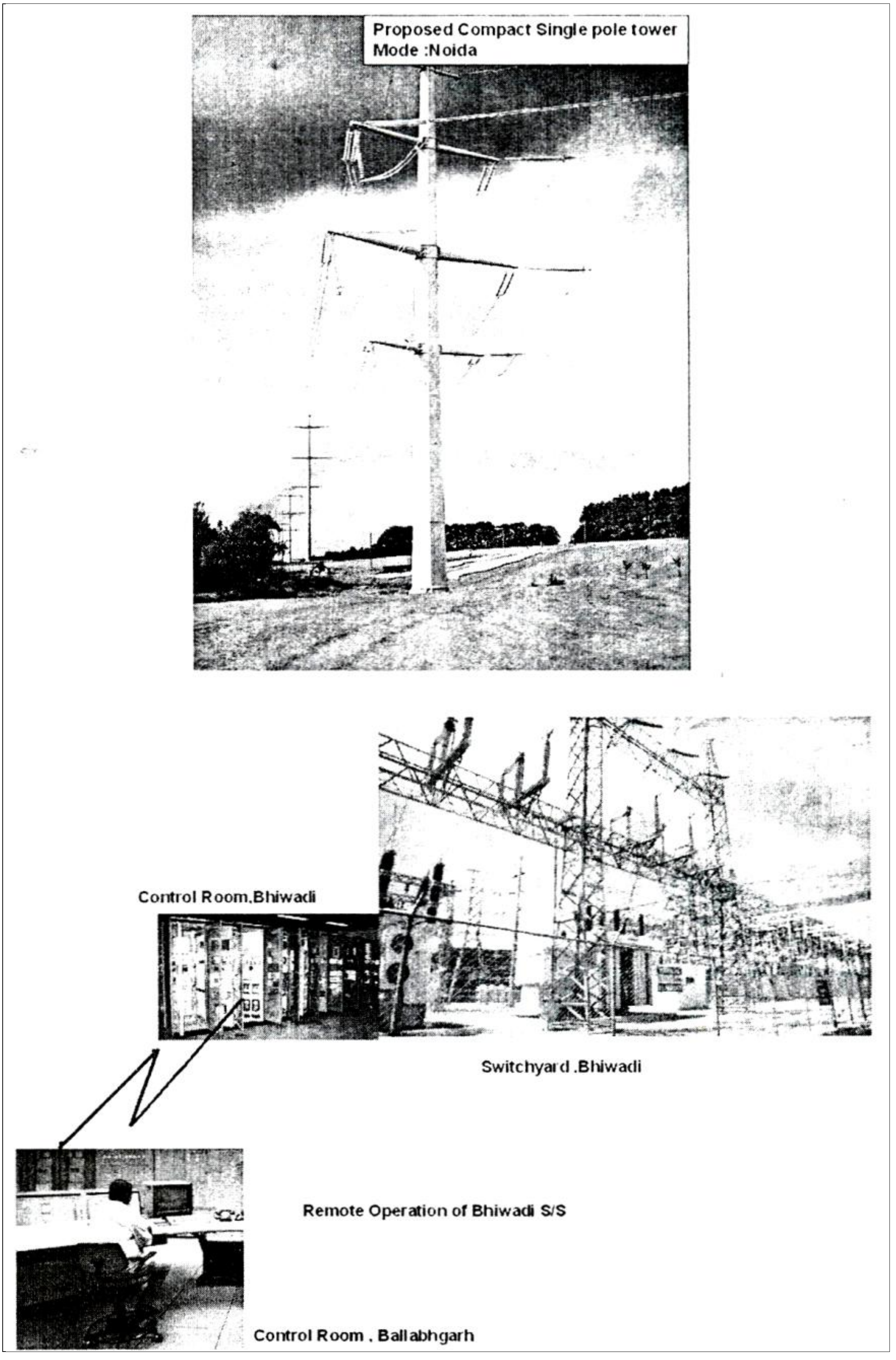
High Temperature Conductors for increased Loading

Automation of Sub-stations





Forest & Wild Life Protection
50MTRS
9-25mtrs.
800 kV Normal Tower
800 kV Compact Tower
ROW = 85 Mts
ROW = 64 Mts


Proposed Compact Single pole tower
Mode :Noida
Control Room,Bhiwadi
Switchyard .Bhiwadi
Remote Operation of Bhiwadi S/S
Control Room , Ballabhgarh

Environment & Social Policy & Procedures

Environmental and Social Issues

POWERGRID's own Environment and Social Policy & Procedures (ESPP) in vogue after wide consultation

Social

Avoidance, minimisation & mitigation of inhabited area, tribal area through land management

Public Consultation, health & safety

Progressive entitlements to PAPs

Integrated Transmission System Planning

Integration of transmission system required due to regional imbalances in demand & supply

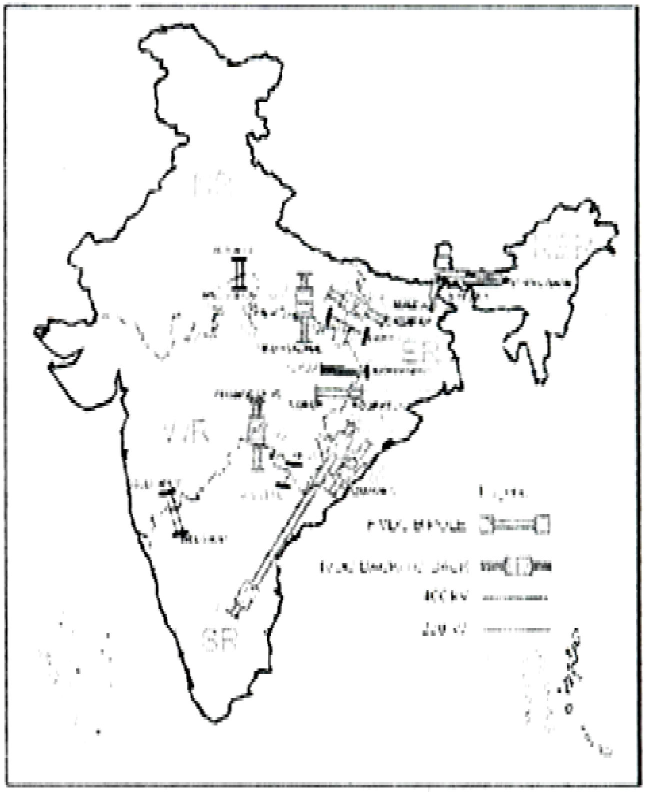
Integrated Transmission system with inter regional power transfer capacity of 37,000 MW by 2012

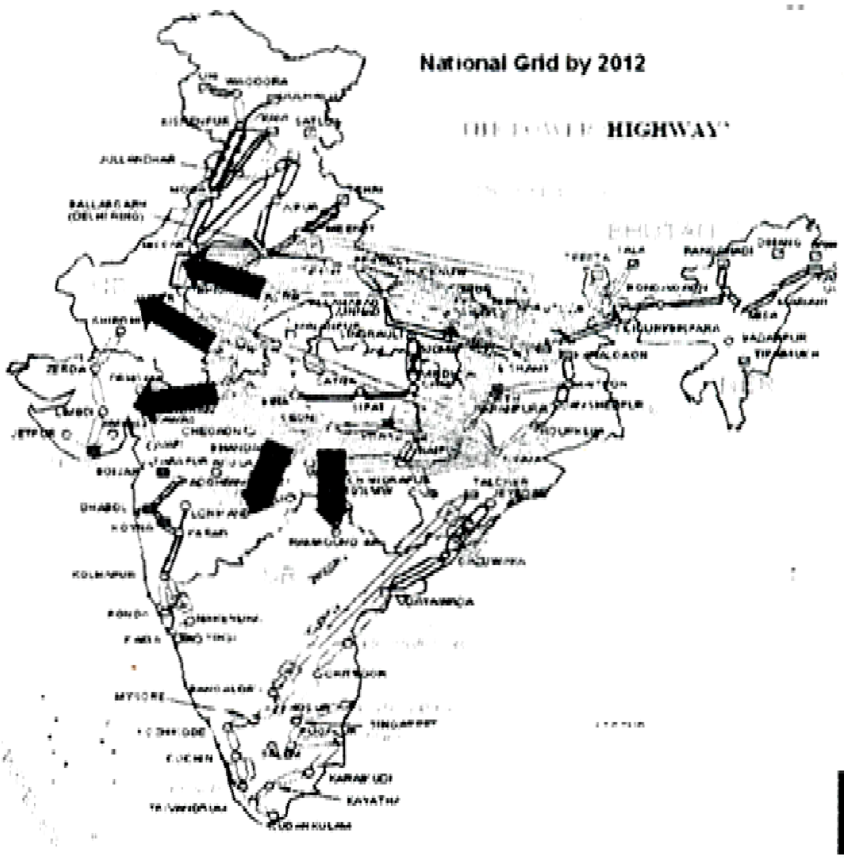
Inter-regional power transfer capacity of 9500 MW already established by POWERGRID

This will lead to reduction in capacity addition by about 15,000 MW, thus saving investment of Rs. 65,000 Crore

Hybrid transmission system having high capacity HVDC and EHVAC links for smooth, secure and reliable power system. HVDC links with its control features for power flow modulations and Power Oscillation damping controller would provide an important tool in National Grid Operation.

National Grid - Present





Status of Distribution

Wire Business

55% of households in the country still do not have access to electricity

In some of the States both Urban /Sub-urban electricity infrastructure is 30 to 40 years old

In some States, it has been gradually improved but not in line with the growth envisaged in future to meet "digital grade price smart" power

Rural electricity infrastructure, wherever exists is mostly outdated and very old and O&M is generally neglected

Thus quality of power supply is totally unreliable

Status of Distribution

Collection Business

Meters are either unreliable or not in place

Meter readers not in position or deficient

Ad-hoc billing

Transparent communication with the consumers missing. Thus they are unaware of the cause of non-delivery of power

Consumers thus reluctant to pay dues as their need not been fulfilled

This has created "catch 22" situation in Power Sector
i.e. Consumers and Utilities have no trust in each other

POWERGRID's efforts for improvement in Distribution - APDRP & RE Works

APDRP programme of GoI aims at strengthening and upgrading Sub-transmission and Distribution systems in States with objectives of reduction in losses, bringing about commercial viability, reducing outages and interruptions and increase of customer satisfaction

POWERGRID is acting as Advisor-cum-Consultant in 179 distribution circles / towns / schemes spread over 18 states at a total cost estimated cost of Rs. 7900 Crore.

Rural Electrification schemes for 2400 villages in Bihar along with 33 kV backbone at an estimated cost of Rs. 175 Crs are being executed by POWERGRID

Objective & Strategy of POWERGRID for R.E & Distribution works

Reliable and quality power to all villages/consumers

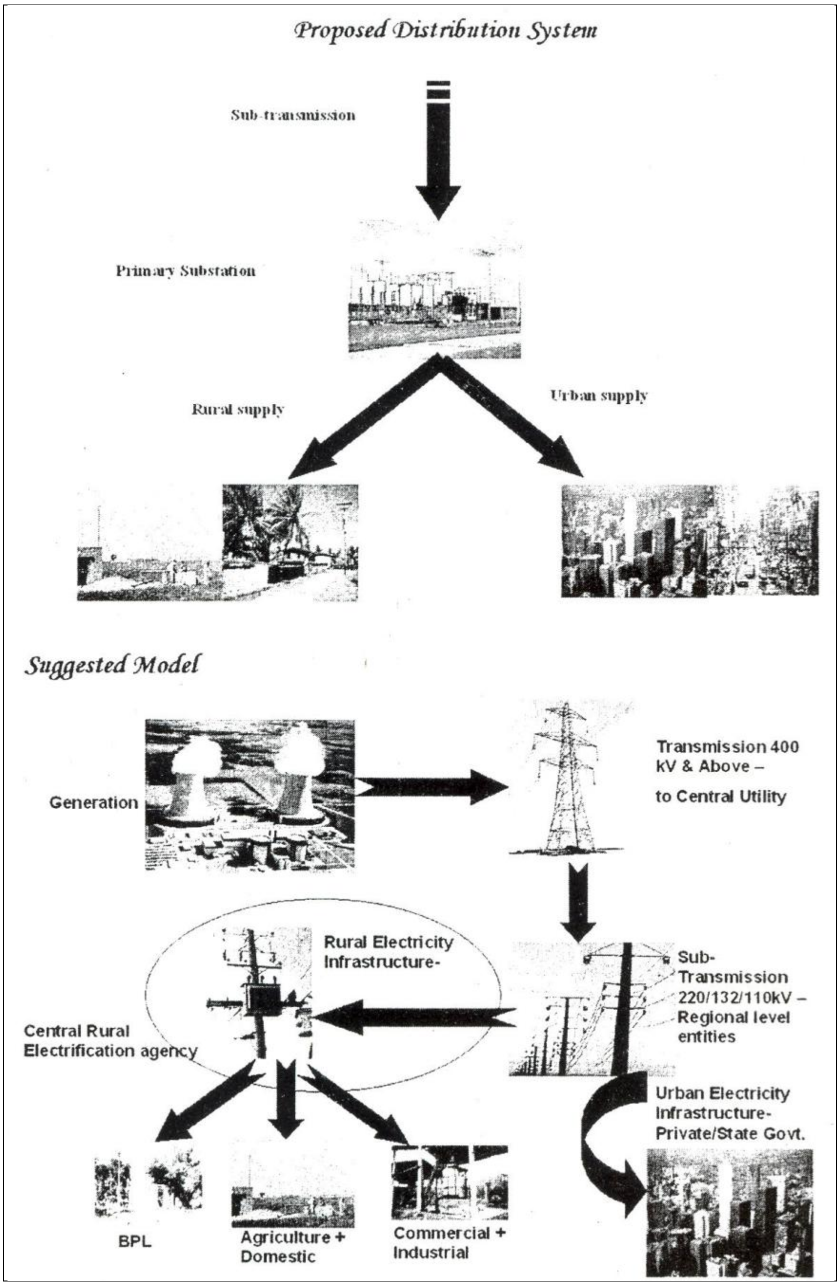
Comprehensive planning & design preceding implementation

e.g for RE works. planning starts from District level coming down to Block & ultimately to Village/Consumer levels

Use of Modern Technology. like HVDS in Distribution & RE

Use of IT

Quality control – from Design. Manufacture of equipment to installation & commissioning



Need to segregate Urban & Rural Distribution System

Beyond Sub-transmission. i.e Distribution infrastructure for delivery of power to Urban/Sub-urban and Rural areas are still integrated. hence lacking focused attention towards development of Rural sector

Private entities are reluctant to take up Rural Electrification as it involves –

- High subsidies
- Remotely located
- Wide spread area -high cost of installation and maintenance
- Having low return as energy consumption is meager

Urban/Sub-urban –

- Development. O&M of Distribution infrastructure may be Privatised/continued with State Govt.
- Power supply to the consumers including metering. billing and collection may be assigned to Private entity(s)/local bodies or their Franchisees

Rural Electrification

GoI is providing 90% grant for Rural Electrification. This includes -

- Modernization and upgradation of existing distribution system in already electrified villages
- Establishment of new network in un-electrified villages

However. most of the States lack abilities in -

- Project formulation considering long-term 20-30 years goal
- Project implementation including contract management with a purpose to shift towards completely outcome-driven project
- Subsequent Operation & Maintenance
- Efficient Billing & Collection mechanism

Benefits of subsidy by GoI grant is not visibly reflected

Wire Business & Trading Business -separate Identity

"Wire business" and "Trading cum Collection business" should be treated as separate entities. hence need to be separated. This will ensure reliability and availability of the much desired "wire business" & segregated from the risk of collection

To make "Wire business" viable -

- Enhance the 90% GoI grant to 100%
- Provide GoI grant for O&M @2.5-3% of project cost

Much talked about open access could be operationalised at the lowest level

Rural Electrification – Wire Business

For wire business. a central Rural Electrification agency may be established with the responsibility of

- Development of Rural Electricity infrastructure including uprating / upgrading. and
- O&M of the infrastructure

Above grant for creation of infrastructure (100%) and O&M(2.5-3%) may be transferred to the Central agency

Those States who desire to implement on their own. 90% grant may be extended.

However. their project formulation. procurement. implementation. O&M etc. shall be approved and monitored by the Central agency

Rural Electrification – Trading & Collection

Responsibility of supply and collection to Local bodies/Panchyat or their Franchisees who will -

- Pay to Generators, Transmitter & Sub-transmitters
- Provide new service connection to
  - BPL consumers through 100% GoI grant
  - Other consumers at their own cost
- Installation of meters
- Billing and Collection
- Localised O&M

Rural Consumers may be categorised into three(3) types

- Commercial & Industrial
- Agricultural & Domestic
- Below Poverty Level (BPL)

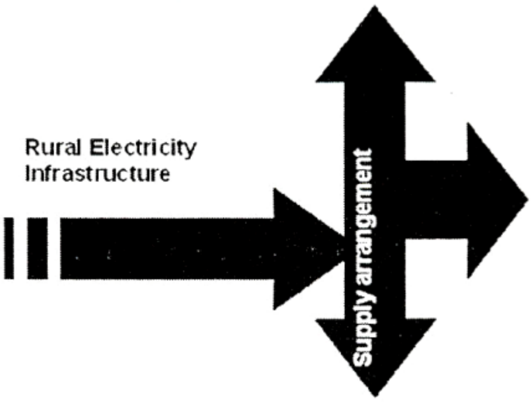
to be charged at three different rates

Suggested Pricing Mechanism

Agriculture + Domestic

Price = Say Rs. 2.1per Unit – does not include cost of rural infrastructure (Rs. 0.6-0.7 per unit) – ***a visible subsidy by GoI grant***

Rural Electricity Infrastructure



Commercial + Industrial

Price = Actual Cost, Say Rs. 2.8 per Unit

Below Poverty Level (BPL)

- **Single meter for cluster of houses with Rationing of supply (limited energy)**
- **Charges to be recovered from the additional revenue collected against rural infrastructure (0.6-0.7 Rs/unit) charges from the Commercial & Industrial consumers + State Govt. grant**

Summary

The suggested model for re-structuring of Distribution sector shall enable

Power availability with reliability & quality from generators through efficient Transmission, Sub-transmission and distribution system to Rural areas

The benefit of the grant being given by GoI for Rural electricity infrastructure development shall be transparently & visibly passed on to the rural consumers

Subsidy arising out of GoI grant gets reflected in the pricing mechanism of electricity to rural areas including BPL

Rural Electrification infrastructure is totally isolated from Urban areas and shielded from the risk of collection.

The much talked about, and seen as a solution towards commercialization of the Electricity Sector i.e ***OPEN ACCESS*** can be implemented through assured connectivity with desired reliability

6. Communication Networks

Crucial for effective management of the Grid

National Load Dispatch Centre (NLDC), Regional Load Dispatch Centres (RLDCs) & State Load Dispatch Centres (SLDCs)

NLDC : Being set up by POWERGRID

RLDCs already set up and being managed by POWERGRID

State Load Dispatch Centre (SLDC) backed up by sub state Load Dispatch Centre

Communication Networks

Transparent communication exists between RLDCs and SLDCs

Similar transparency needed between SLDC, distributors and consumers

Transparency and effective communication leads to

- **Common awareness**
- **Commercialisation**
- **Economy**

Features of LD&C Systems

All constituents get the same data in real time.
- Transparency & Synergy in operation.

Quantum leap in visibility to operator.
- Increased confidence & Focus on security and economy.

Preemptive, dynamic "early warning" systems.

Grid less vulnerable to disturbances.

Accurate and easy analysis of grid incidents

Faster restoration after perturbation

Comprehensive energy management system functions
- Contingency evaluation, Security assessment and State Estimation

Grid Performance

Grid Disturbance

No major Grid Disturbance in last three years

No. of Partial Grid disturbances reduced from sixties / seventies to single digit

Frequency

Frequency excursions mostly in the operating band as specified in GRID CODE

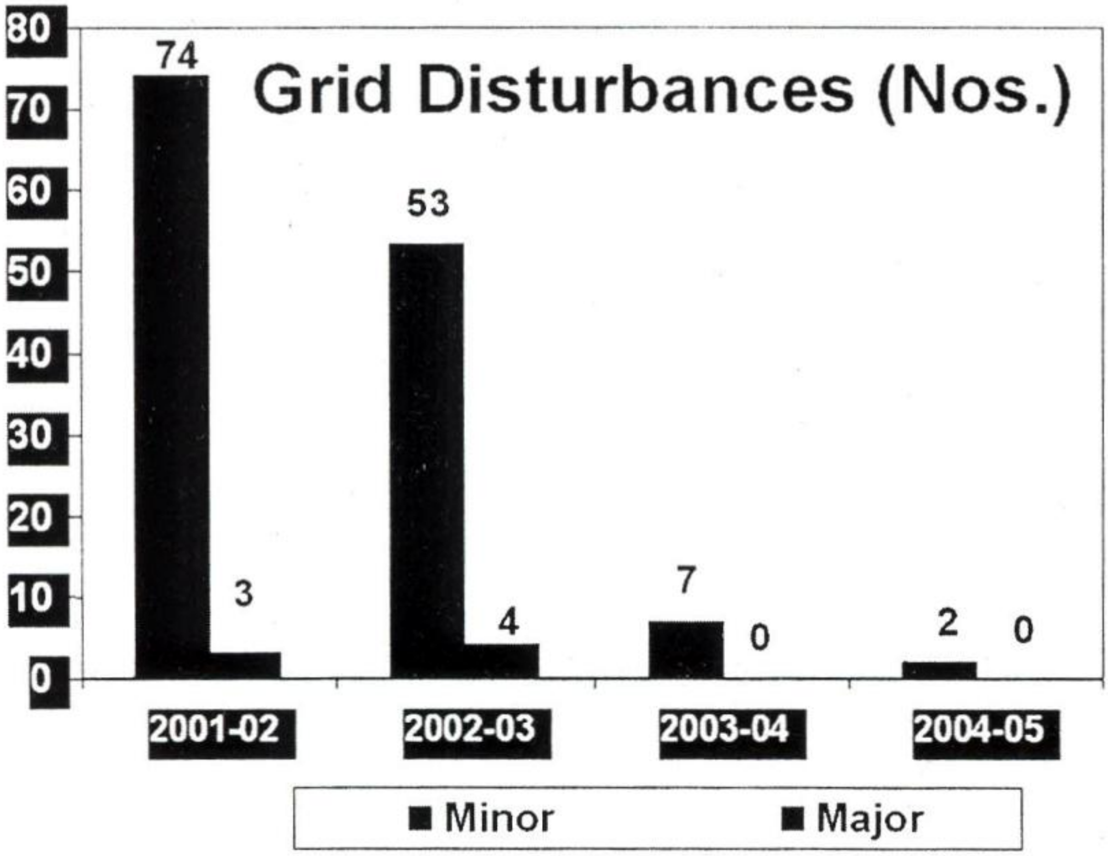
Voltage

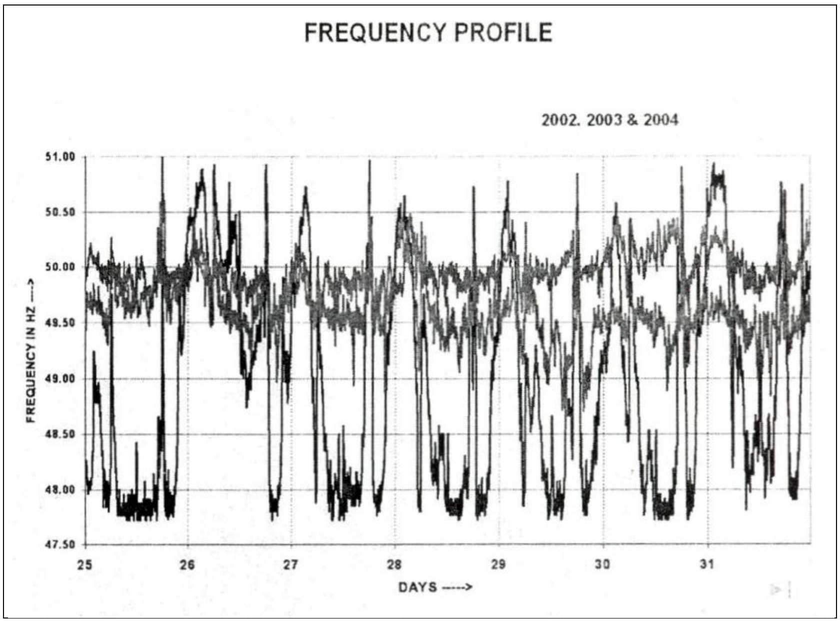
Improvement in voltage profile

Inter-regional exchanges

Increased from 8,230 MUs (2000-01) to 31,000 MUs(2004-05)

Higher peak / consumer Demand met from existing generating capacity




FREQUENCY PROFILE
2002. 2003 & 2004
FREQUENCY IN HZ --->
51.00
50.50
50.00
49.50
49.00
48.50
48.00
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26
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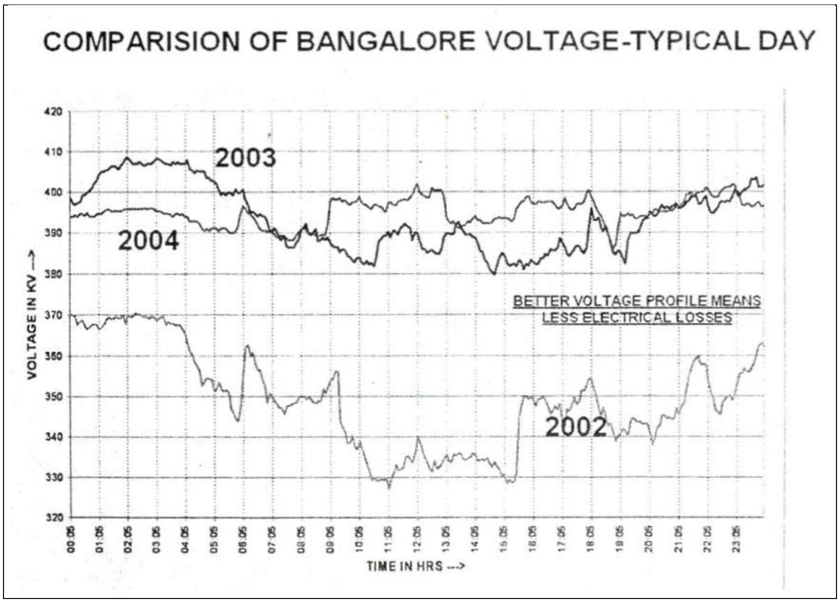
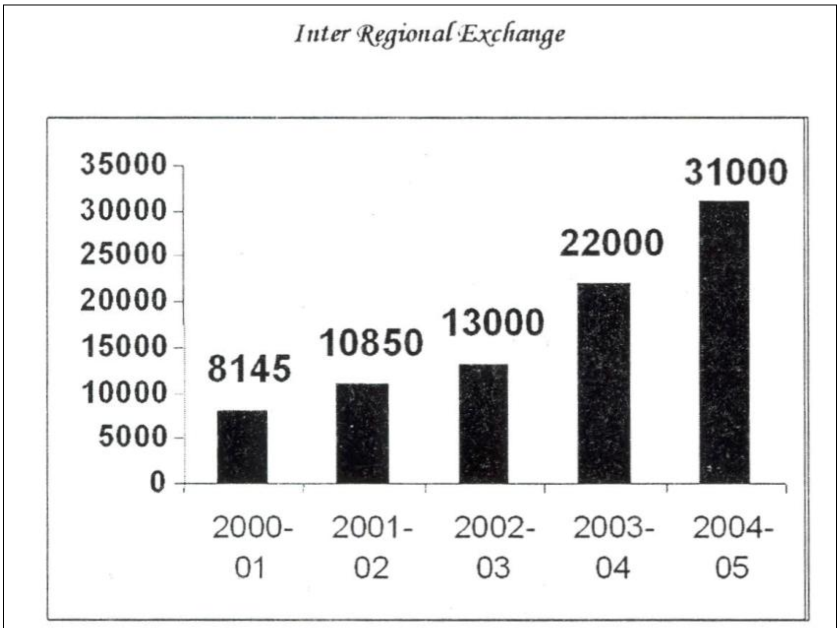
29
30
31
DAYS ---->


COMPARISION OF BANGALORE VOLTAGE-TYPICAL DAY
VOLTAGE IN KV --->
2003
2004
2002
BETTER VOLTAGE PROFILE MEANS
LESS ELECTRICAL LOSSES
TIME IN HRS --->


Inter Regional Exchange
35000
30000
25000
20000
15000
10000
5000
0
8145
10850
13000
22000
31000
2000-01
2001-02
2002-03
2003-04
2004-05

Conclusion

Increase in Generation – more reliance on Nuclear & Hydro

Hydro Authority with clear responsibility and Authority

Harnessing non conventional energy resources

Development of strong National Grid

Create power hubs – Transmission Highways

Strengthening the sub-transmission and distribution network

Sustenance through people --Right people at the right place

Thank You

The Forty-first Nidhu Bhushan Memorial Lecture was delivered during the Twenty-first Indian Engineering Congress, Guwahati, December 21-24, 2006

Looking Ahead

Prof (Dr) D N Buragohain

Former Director
Inditan Institute of Technology, Guwahati

A Fantastic Voyage

The post-World War II era has been variously described as The Third Wave, Post Industrial Society, Post Modernism, Space Age and Information Age. The scale and pace of development during this period have been so great that the impact of the changes during this period on human civilization far outweighs that of all the changes that had taken place from the beginning of civilization till the start of this period. It has affected the life of every individual and every nation, and India is no exception. India's independence coincided with the beginning of this era, and people of my generation who were born before India became free, grew up when the country, after independence, was engaged in planning for the future. In a way our generation has been fortunate that we have been witness to the changes that the world has undergone and, in particular, the country has undergone during the last six decades after independence, and we ourselves have been a part of that change. Indeed the rapid pace of changes brought about by science and technology to our lives have led futurologists to predict that the next twenty years will see as much innovation as the last five hundred years. Recently I read a story in the context of future engineering challenges. With names of individuals and places changed to the Indian context, the story runs thus:

'This morning at seven o'clock, Natasha is not feeling so well. PhD in engineering sciences, she is the youngest associate member of the Firm Smith and Associates. She has a full negotiation journey ahead in Delhi. It was not easy to rest in bed with the amount of important points running around in her mind. The subject of negotiation is a large contract for the design of a ten-story building, considered essential for her firm. She knows that the first thing to assess this morning is her physiological and mental condition. She switches on the HPSS (Health Parameter Sensory Scanner), sits in the chair of the machine and waits several minutes until the green light indicates the end of the scanning process.

She is in good shape, some stress sensation due to the big responsibility on the important contract to negotiate, nothing to worry about. Next step is to switch on the PC, run the program PAMT (Psychoanalytical and Mental Test) and answer a battery of questions. The result shows the need of some resting in order to be in optimum mental condition. Prescription: either an hour resting or a pill of 'Prozac'. She has no time; she takes the pill.

After a small breakfast she is ready to drive her BMW. The VACC (Vehicle Analysis and Car Control) was programmed by Natasha the night before, for the purpose of being sure that every single car subsystem is in good shape and ready for the trip. VACC switched on the heater some time earlier, the engine on time, cleaned the shield and windows, checked' every level of the car fluids, and tested the safety devices. The BMW is in perfect condition.

Today is January 15. Natasha requests information about her trip using the CNSS (Communication Navigation and Safety System). The present traffic in the Jaipur - Delhi highway is relatively fluent; the trip' between Natasha's home and the Architect's building in downtown Delhi, can take 34 minutes. The streets on the way to go are clearly marked in the GPS map; two alternatives are possible in case of jams. At the convenient corners Natasha will be advised of possible changes.

Natasha has decided to maintain control of the car driven system. Once in a while the screen connected to the CNSS, requests slowing or increasing speed. A security distance with the cars surrounding Natasha's BMW is essential. The system advises also of the best lane to drive at every moment for the most efficient, faster and secure trip. At some point in time the CNSS announces at the screen a small accident in one street Natasha is supposed to take. Few seconds later the screen is showing her an alternative itinerary. At exactly the programmed time Natasha is sitting in the meeting room of the Architect ready to negotiate the contract for the design of the ten-story building. Her physical and mental conditions are OK. The contract negotiations are a full success for the Firm Smith and Associates.'

The story is set in the year 2023. It is certainly fiction, and so are the systems HPSS, PAMT, VACC and CNSS. But today we do not doubt that the story can become a reality, and the systems can come into existence if the engineers in the 2020-decade design and develop them. In fact, we are no longer shocked to find something utterly unthinkable a decade ago becoming a part of our day to day life. The changes have been so fast and continuous that it has become almost impossible to coin a single appropriate name for the present age.

The scientists and engineers who developed methods for analysis and design, and built roads, bridges, houses and irrigation systems, and designed and developed machines and tools, medicines and surgery devices, cars and ships, airplanes and satellites, computers and mobile phones, have created an environment much more comfortable today than the one of our parents. This is true irrespective of whether we live in a developed country, or a developing country or an under-developed country. Only the degree of comfort and quality of life differs.

Years ago, during the 1960's, there was a science fiction movie about a 'fantastic voyage' in which members of a medical team shrunk to the size of microbes to travel through the blood vessels of a patient to explore and rectify defects in the system. What was purely fiction at that point in time, could well be a reality in not too distant future with nano-robots injected into the blood stream to carry out similar jobs.

For mankind, it has indeed been a fantastic voyage on the vehicle of science and technology - from the slide rule to the pocket sized computer, from difficulties in communication between places to instant global communication, from lack of knowledge and information to abundance of information on almost anything.

Taking Guard

While we rejoice at the achievements of science and technology and enjoy the resulting benefits, it is also necessary to prepare ourselves for the future so that the gap between the developed and the developing can be bridged. A question naturally arises as to whether we have been active participants in the explosive developments of this age by initiating and pioneering processes that change our way of thinking and the way of our lives. Or, are we clever spectators standing by the wayside and jumping on to the bandwagon of developments made by advanced nations? While it is one way to develop expertise and leapfrog on to the developed world, it is a fact that continued dependence on advanced nations for technology can never succeed in a technology apartheid regime, being practiced by the advanced nations in their own economic interest. While such dependence can produce a band of expert followers, it will rarely produce leaders whose ideas and innovations will be followed by the rest of the world. There is no need to waste time in trying to re-invent the wheel, but people in every strata of society need to be prepared for what is coming. Economic globalization in the information age can only increase the 'digital divide', unless our people become capable of accessing and processing information for their own benefit.

If we look back at the six decades after independence, we will find many success stories for the country. Self reliance in nuclear engineering and space technology, the unprecedented boom in the software industry and the spread of communication network to almost every nook and corner of the country, self-sufficiency in food and advances in engineering education, are some of the notable success stories. Yet, the pace of progress has been slow compared to that of some of the east Asian countries. In some other areas we have not succeeded at all. We seem to be reluctant to tackle some of the recurrent problems - like floods and droughts - that lead to huge loss to the people and the country almost every year instead of trying to find a solution that will alleviate the problem at least partially. We seem to be bogged down by issues that only create divisions rather than unite people to rise from the quagmire of mediocrity to excel in overcoming obstacles to come to the level of the advanced nations. We seem to revel in dividing and subdividing the nation on any pretext, whether it is majority against minority, privileged against underprivileged, males against females. In this, surely, we have surpassed the British who were supposed to be past masters in the divide and rule policy. This has led to every ethnic group clamouring for separate recognition and privileges. In this cacophony, the interest of India no longer seems to enjoy its due priority.

Even at this information age, some of us seem to be indifferent to the importance of knowledge and information. Even when the information is there, we do not seem to care. During my stay in Mumbai as an engineering student, I was asked several times whether I had taken my passport with me for going to Assam during the vacation. But I was stunned when a professor at one of the IITs asked me whether Assam was in Sikkim. That was in early 1980's. During the early part of this year, the television media carried a BSNL advertisement on 'one India' stating it to be from Kashmir to Kanyakumari and from Rajasthan to Kolkata, forgetting that there was still a part of India east of Kolkata. It was aired for more than a month before Kolkata was replaced by Arunachal Pradesh. Such incidents reflect an attitude of mind that is confined within narrow boundaries. Fortunately, such people form only a miniscule of the population. The people of India have shown time and again that at times of distress, they are one and can collectively find a solution to pull the nation out of trouble.

Thomas Malthus, an English cleric, prophesied in 1798, that England's population growth would lead the country to poverty and mass starvation. Nineteenth-century England survived, indeed flourished, because it was able to counter the demographic pressures upon it through three great developments that Malthus did not foresee: mass immigration to America and other new worlds, the technological improvements in agriculture, and, most especially, the Industrial Revolution. The British press predicted in 1974 that India would face acute famine and starvation deaths by the end of the century because of population growth. India survived and became self-sufficient in food through the 'green revolution'. There is enough ingenuity and innovativeness in the human mind to face and overcome any adverse situation. However, anticipating the future and preparing for it puts us in a more advantageous position both as an individual and as a nation.

What are the concerns for the future that need to be addressed at the present? The International Council of Academies of Engineering and Technological Sciences (CAETS) identified the following engineering fields as likely targets for future challenges:

Materials

Nature has supplied mankind with a lot of natural materials. However, new materials for life, in construction, electronics, chemistry, medicine and consequently in everyday use are urgently needed.

There are four types of materials that playa big part in the arena of new materials: two of them are inorganic (metals and ceramics), one is organic (organic polymers) and the last, but not the least, is bio-material.

It is a challenge for researchers and engineers to bring these four types of materials in various synergic combinations to develop newer materials with special properties not obtainable in natural materials.

Climate

Climate variability has determined the fate of entire communities in the past and continues to affect the activities and production systems of modern societies, forcing them to a continuous process of adaptation. The twentieth century witnessed the birth of meteorology as an exact science.

The technological breakthroughs in remote sensing and parallel computing then generated an explosive scientific activity in atmospheric sciences during the second half of the century. This evolution of climate from 'art' to science brings it much closer to the more traditional technological areas with strong background in physics, allowing for interdisciplinary work and research.

Energy and the Environment

The fossil fuels play dominant roles in the world's energy supply. Measures to decrease carbon dioxide emissions will thus greatly affect the ways in which we use fossil fuels and non-carbon dioxide generating sources of energy. The transfer into the hydrogen energy economy may be the energy solution of the 21 st century.

Education

With information available on the internet and with distance learning facilities becoming feasible, the conventional class room could well be on its way out. Students can join virtual schools in which students from different states and countries come together chatting and learning yet never leaving their homes. The challenge is therefore to design, develop and implement a computer based intelligent tutoring system which would be highly personalized to the needs and attributes of the individual learner.

Biomedical Engineering

Biomedical engineering is the application of the principles of engineering to the solution of problems in biology and medicine, with particular reference to the techniques, devices and procedures used to diagnose and treat patients with disease. Astounding progress has been made in medical science over the last half-century. At the same time, remarkable advances have taken place in electronic and mechanical engineering, computer science and engineering, and in information and communication technologies (ICT). It is not always realised that this medical progress has been, and continues to be, absolutely dependent on these engineering advances. This linkage is exemplified by the introduction of an increasing number of the most varied, frequently extraordinarily complex and sophisticated, electro-medical devices and equipment into everyday medical practice. There has also been an explosive growth in ICT in medical practice as well.

The Human Genome Project was one of the most significant scientific endeavours in the world in the 1990s. The objective was to discover the entire sequence of the genetic code that is the key to health and disease. This massive task involved the identification of all the approximately 30000 genes in human DNA and the determination of the three billion chemical base pairs of which it is composed. The result of this research is that it is now becoming possible to diagnose and predict diseases, all of which, to a greater or lesser extent, have a genetic component, and to develop new and effective methods of combating them. Vital to this effort has been the development of devices including automatic sequencers, robotic liquid-handling equipment and software for data-basing and sequence assembly.

There seems to be no limit to what engineering could do further to revolutionise medical practice and many of these challenges will have to be met to meet the expectations of the society.

Communications

Information and communication are inseparable, since information is the object of communication. The characteristics which brought about the Information and Communication revolution are i) Digitization, ii) Information Processing, iii) On-line Communication, and iv) Access to information through PC's and networking. Information and Communication technologies are in a continuous process of development and the challenges are many, since high technology areas such as Biotechnology, Culture Technology, Environmental Technology, Nanotechnology and Space technology are all based on it.

Digital Divide

'Digital Divide' has been defined as ' the gap between individuals, households, business and geographic areas at different socio-economic levels with regard both to their opportunities to access Information and Communication Technologies (ICTS) and to their use of the internet for a wide variety of activities'. Achievement of an equitable global village, where all the people in the world are able to live a contented and fulfilling life is the only dream, which can save humanity and ensure that major human catastrophes are avoided. The gap between the developed and developing nations needs to be rapidly bridged to ensure a minimum acceptable quality of life for the people in the poorer nations. This can only happen when we are able to build a strong digital bridge and empower weaker nations and societies to reap the benefits of economic globalisation using the tools now available from information and communication technology revolution.

Transportation and Private Vehicles

The emergence of the automobile industry and the boom in its growth have seriously undermined the quality of life by triggering social problems such as energy crisis, air pollution, traffic jam and high level of noise. The increase of vehicle volume has tended to aggravate these problems and has led to social stresses and costs that rise along with the extent of environmental threat as well as the demand for more fuel, traffic capacity, their logistical infrastructures and constructions. Consequently, the whole world has to face the challenges of how to cope with the environmental issues such as identifying energy source alternatives, constraining the harmful and greenhouse emissions, alleviating the traffic congestion and reducing the noise level, etc.

Agriculture and the Environment

Modern agricultural technology, especially genetically modified organisms (GMOs) are a reality and agriculture has to cope with the problems associated with it. The other trend is sustainable development in food production. The third trend is based on integrated pest management (IPM) and integral plant resistivity (IPR). It will be necessary, however, to ensure and demonstrate that genetically modified crops pose no risk to human health and environment.

Robotics

In the science fiction of Issac Asimov, 'I, Robot', three Laws of Robotics were laid down. The three laws are:

A robot may not injure a human being, or through inaction, allow a human being to come to harm.

A robot must obey the orders given it by human beings except where such orders would conflict with the First Law.

A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.

In spite of the fact that the science fictions and animated comics have given vivid images of the robots and cyborgs, the robots found in real life are placed in the factories and they are just arms with end effecter doing repeated simple tasks of moving, assembling, palletizing, painting, cutting and welding. Such robots are said to be industrial robots. In 1996, Honda Motor Co. announced the first humanoid robot P2 which could autonomously walk with biped. Since then, other humanoid autonomous biped robots have come into existence.

When computers and sensors are used, the robot can turn out to be intelligent. The definition of this intelligence is said to be the ability to adapt to the varying environment. To have the ability to adapt to the environment, it is necessary to have the following functions.

- Information and data acquisition using sensors and through communication
- Data storage in the data base
- Logics to structure and use the data
- Interaction with the environment

It is expected that in future more number of robots and more kinds of robots will be used in the society, and they will play an important role in all fields of human activity to improve the quality of life.

Reuse and Recycling and the Environment

One of the negative consequences of modernization is the production of waste at an increasing rate. It will be essential (i) to reduce the generation of waste material, (ii) to recycle them and use them as raw materials for other processes, and, (iii) to ensure their appropriate final disposal.

Security

Security in our daily lives is essential to maintain the quality of life. There are threats from terrorism, drug trafficking, economic risks, and cybernetics risks or the 'war of informatics' in which one sees the possibility to annihilate or destroy the resources of a society.

Water Supply and Human Survival

Water has always been considered by mankind as vital for its existence on this planet. This explains why many ancient civilizations thrived around natural water bodies. Apart from the challenge of supplying potable and uncontaminated water to large cities and the growing population, there is need for water supply for agriculture and food production, industrial water supply, water supply for arid and semi-arid areas and to develop new sources of drinking water.

These are some of the challenges of future engineering. Getting acquainted and working with them, we can expect to be better equipped to shape the future, or, at least learn to cope with the future technological revolutions.

Into the Future

Mankind has always been fascinated by predictions about the future. It is the dream of every individual to be able to shape his own future. While predictions about the future on an individual basis may not be possible on a scientific footing, it may be possible, judging from present trends, to make a calculated guess about what the future holds in the field of science and technology. Technology companies often engage futurists to guide them into research that is likely to result in products that make a profound impact on the society. Yet, more often than not, most of the transforming technologies are almost never envisioned in advance, but instead are appreciated after the fact.

In an interesting counter argument, Lee Gomes has this to say about predicting future technologies:

'Technology companies are often described as 'inventing the future.' Maybe they do. But they aren't very good at predicting it. That's how it is with the future: You never quite see it coming.

Let's not discount out of hand the idea that something unforeseen might appear on the scene to change things. Just don't expect to recognize it for what it is right away.

People in the technology world are forever searching for the 'killer app' - the must-have sure thing that the whole world will want to buy. Invariably, though, they never find the killer app; it finds them. You wake up one day and realize that you can't remember how you ever got along without, say, search engines.

It's a problem for technology companies. Most of the really transforming technologies bubble up in unexpected ways. More often than not, they require some sort of existing infrastructure, which they gently nudge in the direction of additional usefulness. The Internet, for instance, would never have happened without a vast and efficient telephone network, not to mention tens of millions of powerful pes'.

Whatever may be the way the transforming technologies enter our lives, it is always rewarding to be at least partially ready for them, so that we become a part of the change instead of trying to adapt ourselves to the changed environment all of a sudden. Alvin Toffler has aptly described these aspects of the rapidly changing technology and socio-cultural scenario in his books 'Future Shock' and 'The Third Wave'. Many universities have now introduced courses in 'Future Engineering' to prepare students for future challenges in engineering and technology. Although history is littered with visions of the 21 st century that never came true, big companies still employ futurologists to make radical predictions about the next few years.

The latest technology predictions released by British Telecom suggests hundreds of different inventions for the next few decades including:

- 2012: personal 'black boxes' record everything you do every day
- 2015: images beamed directly into your eyeballs
- 2017: first hotel in orbit
- 2020: artificial intelligence elected to parliament

• 2040: robots become mentally and physically superior to humans
• 2075 (at the earliest): time travel invented

We have to bear in mind that futurologists are not trying to make them happen, they are just considering the implications of them happening. As far as robots are concerned, the majority opinion is that: 'I think robots will clean our rooms. They already wash our dishes. But I don't see them developing autonomy. I do like it as a science fiction plot'. Others weren't as sure and were worried that there already is too much reliance on technology and lack of control of it, and that the future could bring further dangers. However, Paul Satto, a fellow at Palo Alto's Institute for the Future, offered this in his response: 'Fear of enslavement by our creations is an old fear. But I fear something worse and much more likely – that sometime after 2020 our machines will become intelligent, evolve rapidly, and end up treating us as pets.'

In a study on the impact of the Internet, Janna Anderson, an Assistant Professor at Elon University, reviewed and catalogued forecasts made by technology experts in the media during the 1990s. She found that they predicted, quite accurately, that Internet users would take on multiple identities, as many have with avatars and in popular online virtual reality games such as Second Life; that GPS would be combined with a transmitter and tiny computer to allow people to track their teenage children; and that the information superhighway would get clogged as users send larger files through the Internet.

In another scenario, Anderson suggested that technology could advance so quickly that people would not realize they had lost control until it was too late. Anderson leaves open the possibility that most of the predictions could come true in the distant future: that people will have to deal with the legal rights of robots and whether humans can marry them; people will be able to get video tattoos; and that we will shop using virtual reality booths. 'It's pretty tough to predict wrong,' said Anderson. 'You never know for sure what will happen.'

Ian Pearson, British Telecom's futurist-in-residence, rattles off future technologies that range from the seemingly magical, such as supercomputers that breed like yoghurt cultures, to using your mobile phone in the mundane act of finding your mates at the pub. Pearson says that within a generation, we will grow computers from biological cultures that are faster than those we today construct in silicon, gold and plastic. 'We're looking at the idea of making conscious computers, and it's possible any time after 2015 that we could have computers as smart as human beings,' he says. 'That has a major impact for mankind, whatever way you sum it up.'

'Already you can use DNA to assemble electronic circuits, very simple electronic circuits, but the DNA itself is a little tiny machine,' Pearson says. 'In 15 years time you could design a bacterium (similar to yoghurt) with the DNA in it to assemble circuits within its own cell. Because it's part of its DNA, it will be able to reproduce. So as long as you provide it with a food supply, this bacterium will become a quite large computer over a period of time. It will just breed.'

With the merger of information technology and biology comes the possibility that we will merge our minds with machines, says the British futurist. Education will be a doddle because we will have intimate access to the world's information or any of our gadgetry in a nanosecond. And if 'you have a back-up of your brain on the computer, you don't die,' he says.

Pearson says 'ultra-simple' computing will be a reality in just 10 years. Everything of any significance - clothing, paper or dinner plates, for instance - will contain some form of computer. These computers will be a millimetre or less in diameter and will not be visually intrusive. Large PC boxes in the office will disappear and paintings on the wall will become computer displays.

Fantastic, is it not? The list of predictions is endless, the possibilities bordering on the magical.

Tamim Ansary, well known author of books on culture and society, lists his nominees for the eight greatest inventions of the next fifty years. They are:

Newfangled Super Power Source

After fossil fuels are gone, one of two things will happen. Civilization will shut down or we'll switch to some other energy source I can't see our busy little species giving in to option one. Giant mirrors will orbit the Earth, collecting solar energy and focusing it on power stations below, whence electricity will be distributed to all.

The Waste Converter

Inventors like Ray Kurzweill (a modern Edison) talk about self-replicating microscopic robots that will be able to manipulate matter at the molecular level. Once oil is gone, we'll need a new source of plastic. Fifty years ago, plastic was the new garbage. Fifty years from now, garbage will be the new plastic.

The Weather Wand

Mark Twain once said, 'Everybody talks about the weather but no one does anything about it.' Now it turns out we have been 'doing something' about the weather-warming up the world by burning fossil fuels. And we'll burn what's left in a hotter, faster fury, because nations like China and India are industrializing-a billion more cars will make a difference. Once we realize we can change the weather, we won't put up with inconvenient weather anymore. We'll use those space-based mirrors and stuff to manipulate high and low pressure zones and ensure sunshine. Rain will fall only at night. Man-made breezes will herd smog.

Biological Identification Card

Someone will invent a nontransferable ID based on biological markers such as DNA. You'll have to submit a hair to buy a beer or board an airplane. Or the identi-tag might rely on some other unique tag such as a person's brainwave patterns.

Automatic Personalized House

Today, you can wake up to coffee already made by an appliance that "knows" your schedule. To some of us this seems like personalized comfort carried to an extreme. But every comfort level becomes normal, then indispensable, then inadequate. Futurist Glen Hiemstra predicts that within a decade, houses will routinely have up to 100 computers "embedded in all kinds of appliances and amenities," the way today's houses have plumbing and electricity in their walls.

Dr X's Patented Genetic Cure-All

As it happens, medical researchers are currently unlocking the genetic anomalies that cause such illnesses as Parkinson disease and multiple sclerosis. Cancer can be described as a genetic disorder--as outlaw cells that start multiplying randomly in defiance of their genetic code. Research aimed at defeating genetic and degenerative disorders may also turn up the cure for cancer. After that, people will routinely live into their midhundreds.

Artificial Sense Organs

My friend Mike Chorost is completely deaf but can nonetheless hear, thanks to a cochlear implant. This computer chip implanted in his skull stimulates his auditory nerve endings directly, giving him sensations that correlate to sounds. His brain has learned to interpret these sensations, and thus for all practical purposes he can now hear.

Neurostimulation technology can be applied to other nerve cells. A nerve is a nerve is a nerve. Retinal implants, for example, may enable the blind to see. The hardware will not necessarily be limited to the range of signals human senses can register. People with digital implants might someday see like hawks and hear dog whistles. External hardware may also extend the senses. Steve Pittman, a technology consultant with IBM, thinks we're on the verge of inventing self-adjusting glasses that provide telescopic or microscopic vision, depending on where the viewer is focusing.

Instant Sleep Chamber

The one invention in the Museum of Future Inventions that I know about is the Instant Sleep chamber, which gives you the benefits of a full night's sleep in seconds.

Those who dispense with sleep gain seven or eight hours a day. They could spend that time working, while their competitors slept. In a dog-eatdog world, they would get an overwhelming edge.

So, if an instant sleep chamber were invented, it might indeed take hold, even if no one wanted it, because even though necessity is the mother of invention, invention can also be, and very often is, the mother of necessity' .

In a much lighter vein, I came across this wish list of a house wife for top ten future inventions, in the Internet;

Free Energy

I want my energy bill to come only once, not every month. So be it solar or electro-magnetic, please make it personal and portable with batteries that keep going and going.

Transporter

What kind of technology is required to scramble a person's atoms and send them for regrouping in foreign lands all in the blink of an eye? Imagine, I could work in Tokyo and sleep in Paris. Beam me up.

Replicator Technology (Stuff for Free)

Every time I saw Captain Picard (Star Trek Next Generation) ordering his Earl Grey Tea or Councilor Troy getting a triple alien fudge dessert from one of those replicators on the Enterprise, it made me jealous. I imagine you could send the dirty dishes back to the void where they came from. BTW, a replicator is a device that uses transporter technology to dematerialize quantities of matter and then rematerialize that matter in another form.

Universal Communicator

Forget long distant bills and roaming charges (especially with me working in Tokyo and sleeping in Paris). I want a very small device that lets me talk and see anyone, anywhere and anytime. All for the price of the device and please throw in the ability for universal translation for a modest surcharge.

The Cure

For you name it.

Fountain of Youth

As a woman I consider this as a no-brainer desire for future technology. The 'Fountain of Youth' was a legendary spring that renders anyone who drinks of its waters permanently young. What is the real future technology that will extend our lives and keep us looking youthful without surgery?

Protective Force Field

To shield me from the sticks and stones.

Flying Cars

I want a smooth ride all the way and I hope it's a convertible.

The Battery Operated Butler did

What can I say - housework sucks.

The Time Machine

I have a few famous inventors I would love to meet in person and the idea of messing with the time-space continuum is exciting as well. The items on this wish list are not really wild dreams but serious works on these aspects are going on in one form or the other.

Concluding Remarks

The list of things that are expected to happen in this century can go on and on. And I have hardly touched upon the wonderful and seemingly endless opportunities in the field of Genetic Engineering and Nanotechnologies. Many of the inventions and predictions may become redundant in the face of more spectacular inventions. After all, who will need a TV or cell phone handset if video images and sound could be delivered directly to our brains or eyes or need electricity if we could produce it in the garden or in a cup using just bacteria and water?

Coming back to the present, we have to realize that while the future holds out immense possibilities of a world where the quality of life and human comfort will be guaranteed, we have to be ready with the necessary infrastructure to be able to absorb and implement those new technologies.

Are we ready with our plans that will bridge the 'digital divide', make our communications and transportation networks smooth and hindrance-free, supply continuous power so that all systems could be kept running all the time, and make life more secure from man made and natural threats? Or, are we just going to let the future overcome us?

The Forty-second Nidhu Bhushan Memorial Lecture was delivered during
the Twenty-second Indian Engineering Congress, Udaipur, December 13-16, 2007

Empowering Indian Minerals and Metals Industry —Way Forward

Shri A C Wadhawan

Former Chairman, Hindustan Zinc Limited
Former Chairman, PESB, Government of India

TRIBUTES TO NIDHU BHUSHAN

It is an honour and privilege to be invited to deliver the 42nd Nidhu Bhushan Memorial Lecture. Although, Nidhu Bhushan was not an engineer in the conventional sense, he had the determination to serve humanity through his knowledge of science. He further inspired us to work with commitment to serve the society without being bothered about name or fame. He was a firm believer in self-discipline, which he rightly thought was the path to success. He was a shining example for all of us to emulate.

I never had the good fortune to meet Nidhu Bhushan. I, however, had the opportunity to meet Prof G D Chatterjee, many times. He was like his father, a very dedicated person to serve his profession, as well as, humanity. One always admired his ideals.

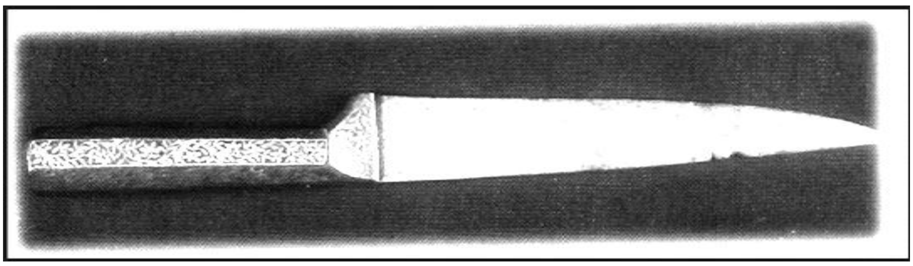
For the memorial lecture, I have chosen to speak on 'Empowering Indian Minerals and Metals Industry - Way Forward'.

INTRODUCTION

It is well known that India had a rich heritage in minerals and metals. Kautilya's classic 'Arthashastra' put it very aptly as early as in the fourth century B C :

'Mines and minerals are the source of treasury
From the treasury comes power to the state'

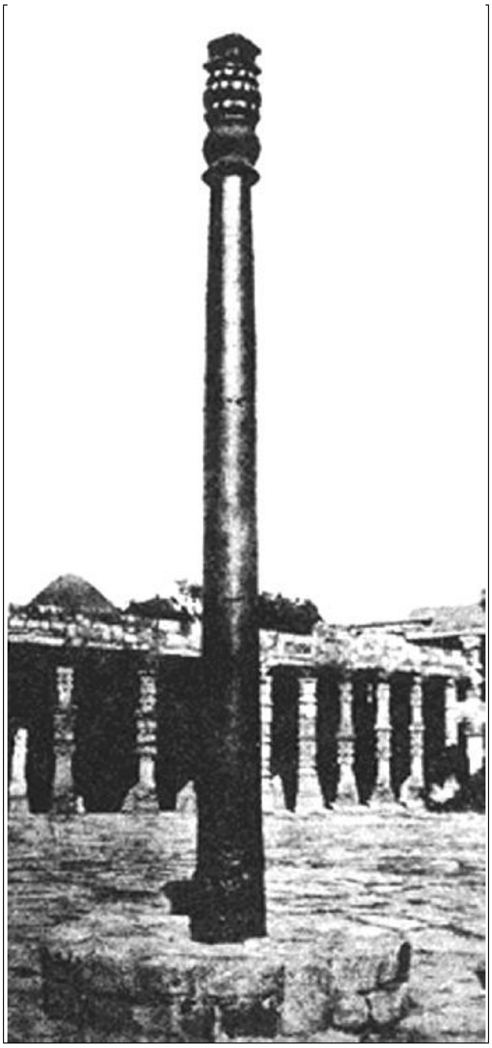
Thus, the economic wealth of the state is largely influenced by its richness in minerals and metals. It may be of immense interest to the people of Rajasthan to know that mining and metallurgical industry existed in ancient times. Archaeo-metallurgical investigations revealed that mining and smelting of zinc in India, centering Rajasthan is the earliest dated in the world - perhaps as far as back as pre-Harappan period. It is also on record that zinc was manufactured several centuries ago at Zawar by using ancient distillation furnaces. These furnaces carried out sophisticated pyrometallurgical operations, a precursor to the high temperature operations of today. The distillation furnaces found at Zawar are divided into two parts : a lower condensing chamber, separated by a perforated plate from the upper main furnace chamber. The retorts rest on the perforated plate which consists of a regular pattern of large holes to accommodate the condenser necks and small holes for the passage of air into the furnace and for ash to drop through. The area in the front of the furnace is paved with large bricks. In the upper main furnace chamber filled retorts rested on the perforated plate with the condenser necks protruding down into the cooler chamber below. The retorts were filled insitu, with charcoal over and around them. The charcoal was also serving as reducing agent. The condensed zinc dropped into the zinc collecting vessels placed beneath. After considerable research work by British Museum, University of Baroda and Hindustan Zinc Limited, they documented the technology and process and this spot has been declared as a metallurgical heritage site by the American Society of Metals.

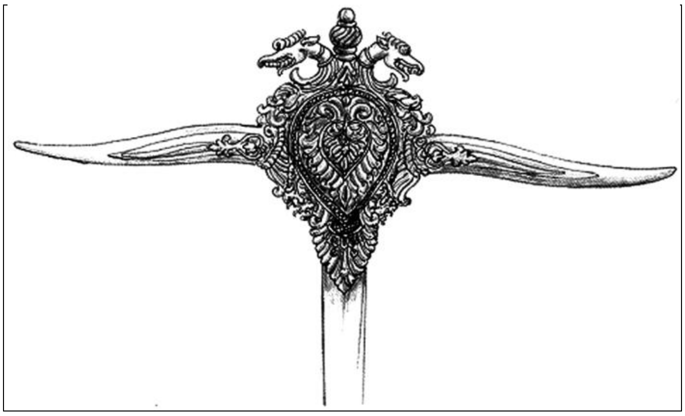


A dagger found in Ooty, Tamil Nadu


Front view of distillation furnaces


A pair of retorts


Iron Pillar at Delhi


Sword from Thanjavur Armoury

The rustless wonder 'Iron Pillar' at Delhi is another standing monument to a glorious Indian tradition in the field of metallurgy. It is amazing how a metallic object weighing nearly 7t could be fabricated over fifteen centuries ago. It is said that the pillar was made by hammer forging and welding ball of pasty iron in many steps. This structure is the earliest and the largest surviving iron forging in the world, recorded as a marvel that has defied the laws of corrosion, even after so many centuries.

India also led the world in developing an impressive tradition of making in South India a high grade steel known as 'wootz'. Wootz steel became synonymous with the Damascus steel since it was used to make the well known Damascus swords. The term 'wootz' was coined when European travellers from the seventeenth century onwards came across the making of steel by crucible processes in Southern India. 'Wootz' is derived from the Kannada word 'ukku' which means steel.

With such a glorious past, India was truly a world leader in the processing of minerals, metals and their products. Somehow, due to a variety of reasons, our pre-eminence in this specialized area gradually declined and following the Industrial Revolution, several other countries soon overtook us and kept their pace of growth and domination for several years.

POST INDEPENDENCE INDIA

When India became free, there were two steel plants, namely, Tata Iron & Steel Company, Jamshedpur and Indian Iron & Steel Company Limited, Burnpur. In the 1950s, three 1 Mt steel plants were set up at Bhilai, Rourkela and Durgapur. Hindustan Aluminium Company came up around the same time and in the 1960s and 1970s units like Hindustan Zinc Limited and Hindustan Copper Limited were also set up for production of zinc, lead, copper etc. All these units were catering to the limited demand within the country.

In India the consumption of steel and non-ferrous metals had a stunted growth initially due to the restrictive policies like import restriction, quota regime, price and distribution controls etc. In this era, our focus in the emerging growth process was naturally power, irrigation, agriculture etc, and this continued up to the 1990s. More or less there was a limited activity with marginal growths in the area of metals and the year 1991 saw a major path-breaking initiative in India, namely, the introduction of macro-economic reforms and the ultimate journey towards a 'free market economy'. As a result, during the last decade or so, Indian metallurgical industry has tried to capitalize on the many benefits of the liberalisation, privatisation and globalisation processes. Today, once again India has become the fifth largest producer of steel in the world, aspiring to become the second largest producer in a decade or so. Currently, India ranks fourth in the production of coal and lignite, sixth in bauxite, manganese and zinc and tenth in aluminium.

Following the economic reforms as well as the massive investments and thrust on infrastructural growth, building and construction, exports etc, there is a quantum jump in demand for steel as well as non-ferrous metals.

Over 100 companies are waiting to sign MoUs, mining leases etc, in the states of Orissa, Jharkhand and Chattisgarh for setting up steel plants. An investment of Rs 5 lakh crores is envisaged, which is over six times the total money ploughed into the sector since independence. This would create a steel production capacity of over 240 Mt, nearly five times of what the country has now. The Indian non-ferrous metals players too are expanding their production capacities and aspiring to come within the 'top ten producers' in the world.

Also during the last few years, India has also gone beyond its shores on a buying spree, looking for opportunities for global takeovers, acquisitions and mergers. While Mittal Steel took over a major steel producer Arcelor in Europe, Tata Steel acquired an Anglo Dutch enterprise Corus in one of the largest buyout operations (US $ 12 billion). Similarly, Hindalco effected synergy in their operations by taking over Novelis in North America (US $ 6 billion). Hindalco and Vedanta have also acquired copper mines in Australia, Zambia and a gold mine in Armenia. In other words, India has come full circle now and bounced back as a major global force to be reckoned with, in the area of minerals and metals. The question now is 'How do we sustain the growth momentum?' The answer lies in how successfully we exploit our inherent natural resources, guided by the long term national goals and perspectives.

MINERALS, OUR CORE STRENGTH

Minerals are finite, non-renewable, valuable natural resources. They constitute a vital raw material to the basic industries and are a major source for development. Management of mineral resources, therefore, has to be closely integrated with the overall strategy of development. It is very essential to achieve the best use of available resources through scientific methods of mining, beneficiation and their economic utilization. India possesses 1.85 million km2 of area, potential for mineral wealth and have a flourishing mining industry, producing 84 minerals out of which 4 are fuel minerals, 11 metallic, 49 non-metallic and 20 minor minerals. India's bauxite reserves are estimated at 2 926 Mt, accounting for 7% of the world's reserves with a life index of 211 years. Similarly, India's recoverable reserves of iron ore are put at 13 460 Mt with a life index of 131 years. Therefore, a tremendous scope exists for augmenting the resource position by further exploration of known deposits and discoveries of new deposits, adopting state-of-the-art technology and modern methods like aerial reconnaissance or geophysical surveys.

MINING OBJECTIVES

The country's accelerated growth rate warrant a rapid development of the mining sector, on which most of the basic industries in the manufacturing sector depend. With increasing competition on account of globalization and the level of technology employed, initiatives for growth in the mining sector had assumed critical significance.

Though it had been the endeavour of the Government of India to encourage greater investment in exploration and mining, there is a need for focused and sustained efforts to increase the investment, both foreign and Indian. A conducive working environment is also called for by removing the bottlenecks which hinder the productivity and efficiency of this sector. This requires changes in the National Mineral Policy to enable attune the present requirement of the world economy.

Broadly our National Mineral Policy (NMP) addresses the key issues :

- exploration for identification of mineral wealth on land and in offshore areas,
- development of mineral resources, taking into account the national and strategic considerations keeping in view the present needs and future requirements,
- promotion of necessary linkages for smooth and uninterrupted development of the mineral industry,
- encouraging research and development in minerals,
- establishment of appropriate educational as well as training facilities for human resource development,
- minimizing the adverse effects of mineral development on the forests, environment and ecology through adequate protective measures, and
- finally to ensure mining operations with due regard to safety and health of all concerned.

PUBLIC ISSUES AND CONCERNS

Thus, the overall objectives of the National Mineral Policy are laudable and well conceived. What remains now is the successful translation of those noble objectives through scientific implementation and investor - friendly policies and guidelines. Obviously, these need the goodwill and support of all the stakeholders including the public at large. Of late, it is increasingly observed that whenever any new industrial or mining or construction activity commences, there are wide spread concerns. While it is difficult to go into their individual merits and demerits, it becomes very obvious that there was no initial effort by the entrepreneurs in creating a prior awareness among the people who legitimately feel that they have not been compensated adequately and/or that their very livelihoods are being endangered or threatened. It is here that the government, legislators, media, NGOs etc, have a greater social responsibility in creating the right awareness and assurance among the public that any new investments in mining, industrial projects etc, are in fact going to generate multiple spin-off benefits and privileges to the very same community, enhancing their standards of living.

GDP AND MINING GROWTH

The economic growth of a country is truly reflected by its Gross Domestic Product (GDP). During the last few years, India's impressive GDP growth has been the subject of intense discussion in many world fora and our country is rightly called the emerging power house/superpower of the Twenty-first century.

The Indian economy has registered a significant growth of 9.2% in 2006-07 as against 8.4% in 2005-06. Mining and quarrying sector as a whole had registered a growth of 4.5% in 2006-07 as compared to 3.6% growth in 2005-06.

The mineral and mining industry including fuel minerals contribute around 2.8% to the GDP of the Nation. Though India has good resources of iron ore, bauxite, copper, gold, chromite etc, without fuel minerals, the contribution is around 0.8% only.

EXPLORATION

Mineral deposits with their high tonnage and grade are capable of maximizing economies of scale and thus have great influence on market factors due to their potential ability to deliver bulk production at low cost and high returns throughout the metal price cycle. Even with low probability of discovery, such resources are great motivators in exploration planning.

The known resources are capable of sustaining current levels of production for the next few decades, with depleting resources being constantly replaced through new discoveries. The progressive discoveries will demand a higher level of exploration technology because near surface, areas of reasonable accessibility and promising mineral potential have already been, or will shortly be well explored. Future exploration investments will have to be made in inaccessible, but prospective terrains, or in those countries which have not witnessed inflow of exploration and development funds.

It is generally observed that many discoveries immediately follow the introduction of either new methods of exploration or improved technology, primarily because each new technique temporarily reduces the cost of exploration with an increased probability of success. To meet the rising demand and to counter continuous depletion of known resources, dedicated efforts are required to discover new economic resources, for which ample opportunities exist, given the highly prospective geology and mineral potential of the country.

The whole objective of exploration is to find an economic deposit in the shortest possible time, and at the lowest possible cost. This is, however, not an easy task. The risk of failure is great and cost is high. Experience in western countries has shown that a find generally requires around 15 years or more with substantial financial inputs. Unlike in the past, it will take highly professional teams using all the state-of-the-art exploration tools available to stand a chance of an economic success, as new ore deposits are expected to be discovered (buried beneath the surface). The three most important ingredients of a successful exploration campaign are, selection of the right geological terrain, optimum level of funding and efforts, and keeping abreast with new technology.

SCIENCE AND TECHNOLOGY

Advanced Techniques

Mineral processing is an essential step in metal extraction process for sectors, such as, ferrous and non-ferrous metallurgy. Continuous endeavours towards fundamental process improvement and explosion of technological advancements has driven mineral processing plants to look for high level of efficiency and consistency in output quality. With the improvements driven by the fundamental research in mineral processing, improved understanding, advanced instrumentation, process modelling, simulation techniques, on-line optimization and control methods, the entire process of mineral processing has now become more predictable and controllable. There are also challenges, such as, handling of uncertainty in ore quality, lack or insufficiency of advanced instrumentation, process changes, adaptation required due to changing process and market conditions, and the business challenge of striking an optimal balance of plant sophistication and cost.

Although Advanced Process Control (APC) and optimization is certainly an effective vehicle to drive successfully towards meeting these challenges, it needs to be supported by methods and techniques to facilitate continuous learning, adaptation and intelligent decisionmaking. Methods to overcome lack or absence of sophisticated instrumentation can be countered by use of a thoughtful mix of softcomputing techniques, statistical methods and data mining.

Bioleaching

With the rapid depletion of high grade ores and concerns about environmental degradation, the necessity for utilising lean grade mineral resources has become all the more urgent. With the advent of bioleaching since the early 1960’s, possibilities of metal extraction in an environment-friendly manner have emerged. As of now three metals, namely, copper, uranium and gold are commercially produced around the world.

Bioleaching of base metal concentrates, such as, those containing copper, zinc and nickel has also been proved to be commercially viable during this decade. Bioreactor technology using bacteria holds the key for the successful and efficient bioleaching of chalcopyrite, sphalerite etc. Microorganisms find use in environmental control and mineral beneficiation as well. Microbially-induced mineral floatation and flocculation have been proved to very cost-effective and environmentfriendly. There has been some effort in development of relevant technologies for recovery of copper, zinc, gold etc in India, during the last two decades or so. However, there has been no viable plant on a commercial scale so far. With abundant lean ores available, it is essential to pay more attention to further develop this technology in association with foreign consultants, if required. This is the technology of the future and we should not lag behind in this field.

Recycling of E-waste

At present India has become an IT power, with massive induction of computers in all walks of our life. These are imported in large numbers and much more is indigeneously assembled too. These electronic gadgets including TVs, cellphones etc, contain some heavy metals and when they are eventually scrapped, they become a source of potential recyclables, generally called e-waste. Here again, we should identify modern and cost effective technologies for recycling them and recovering the valuable metal content in these waste products.

MINING MULTIPRONGED STRATEGIES

In order that we are successful in our mining operations, a multipronged strategy needs to be adopted.

Mineral Conservation

The best use of available mineral resources can be ensured by adopting, during mining operation, effective measures for conservation and beneficiation, recovery of associated minerals and later by efficient processing of minerals. Mine development and mineral conservation should be on a sound scientific basis, with the regulatory agencies closely interacting with R&D organisations, scientific and professional bodies. As an important conservation measure, recycling of metallic scrap like steel, copper, aluminium, zinc, lead etc should be encouraged and facilitated by fixing appropriate standards for classification and grading of scrap and adoption of fiscal measures.

Information about technological changes leading to substitution of the mineral or the products made out of such a mineral shall be compiled and disseminated from time to time to enable the mineral industry to adapt itself.

New Mining Methods

Attempts should be made for augmentation of resource base through improvement in mining methods, beneficiation techniques and utilisation of low grade ores and rejects, recovery of associated minerals, reduction in the requirements of minerals per unit of material output. Indigenous industry for manufacture of mining equipment and machinery should be strengthened. Wherever necessary, imports of machinery and equipment should be permitted to improve the efficiency, productivity and economics of mining operations and safety and health of persons in the mines and the surrounding areas. In order to improve the competitive edge of the national mining industry, emphasis should be laid on mechanisation, computerisation and automation of the existing and new mining units.

The mineral processing unit should not only get an assured supply of the mineral raw material but should also have close links with the production and marketing agencies of the mineral based end products.

Productivity Improvements

Studies for fixing productivity norms and goals need to be taken up to promote productivity of men and machines as well as to improve the consumption norms of fuels and materials.

Human Resource Development

HRD plays a very vital role in the mining sector. At present there is a limited awareness of the huge career/job opportunities available in view of the massive investments in the mining and metals sectors. Opportunities for education and training are limited now and should therefore be expanded. Existing facilities for basic and specialized training should be constantly reviewed and upgraded from time to time to ensure that adequately trained and skilled manpower at all levels is available for the development of mines and mineral based industries.

Research and Development

R&D in the mineral sector has to cover the entire gamut of activities from geological survey, exploration, mining, beneficiation, extraction of minerals to development of materials. R&D should be oriented not only to ensure maximum economic recovery of the prime minerals, but also optimal recovery of the associated minerals and valuable metals. Research organisations should be strengthened for developing processes for beneficiation and mineral as well as elemental analysis of ores and ore dressing products.

Efforts should be directed to the development of new technologies for conversion of existing mineral resources into viable economic resources. Appropriate technologies should be developed to enable indigenous industries to utilise the mineral resources with which the country is abundantly endowed and as substitutes for minerals whose reserves are poor. Efforts should be directed to find new and alternative uses for minerals whose traditional demand is on the wane.

Indigenous technology has to be upgraded through research and appropriate absorption and adoption of technological innovations even from overseas. R&D efforts should be made to improve efficiency in process, operations and also the recovery of main and by-products and reduction in specific consumption norms. Efforts also need to be directed to evolve low capital and energy saving processing systems. Mining methods determine the safety, economy, speed and the percentage of extraction of the ore reserves from a mine. R&D thrust should be directed specially in the areas of rock mechanics, ground control, mine design engineering, equipment deployment and maintenance, energy conservation, environmental protection, safety of operations and human engineering.

Attention must be given to beneficiation and agglomeration techniques to bring lower grades and finer size material into use.

Foreign Investments

Huge capital investments are required for mining and mining-related activities. While India has been investing adequate funds and it is growing in this sector, more FDI inflow should be encouraged. For 100% FDI projects, there is an arrangement for automatic approval of these projects by the Government of India. However, so far, not many projects in India have come with 100% FDI. Perhaps, if the policies at the Central and State levels are made more investor-friendly, including effective implementation of the Single Window Clearance concept, then there is a ray of hope to promote such investment in the Country.

Infrastructural Facilities

A major thrust needs to be given for development of infrastructural facilities in and near mineral bearing areas following an integrated approach for mineral development, regional development and also social and economic upliftment of the local population, including tribal population.

Environment Protection

Extraction and development of minerals are closely interlinked with other natural resources like land, water, air and forest. The areas in which minerals occur often have other resources as well, requiring strategic approach for utilisation of the mineral resources. Some such areas are ecologically fragile and some are biologically rich. The needs of development as well as needs of protecting the forests, environment and ecology have to be properly coordinated to facilitate and ensure sustainable development of mineral resources in harmony with the environment.

Conclusion

'Metals Security' is of strategic importance to India undoubtedly. The growth of our economy is largely dependent on the development of the mining and metals sectors and this calls for a balanced, scientific and integrated approach. India is now at a very critical transition point and can emerge as a major force provided we are successful in implementing and achieving the key objectives enshrined in the National Mineral Policy. As mentioned earlier, there was a time, centuries ago, when India was a leader in mining and metallurgy of minerals and metals. For a long time, knowledge of extraction of abundant minerals went into oblivion. Since, the spurt in economic growth and, therefore, increase in demand, the activities connected with exploration and extraction have increased significantly and it is only a question of time when India will once again become a world power in the production and usage of metals. The state of Rajasthan is the right place to echo this important message loud and clear.

Science, Engineering, Technology and Development

Dato'Ir Lee Yee-Cheong

President, ASEAN Academy of Engineering and Technology
Chairman, Governing Board, UNESCO STI Centre for South-South Cooperation

INTRODUCTION

I am deeply honoured to have been invited to deliver the 43rd Nidhu Bhusan Memorial Lecture on this auspicious occasion of the 23rd Indian Engineering Congress of The Institution of Engineers (India). I understand that the Late Nidhu Bhushan, a science graduate, wanted to be an engineer, since he believed that an engineer has better opportunities to prepare himself for better service to his fellow beings and society. His deep-rooted conviction is music to my ears. I am thus very pleased to speak in honour of his memory.

The two critical and urgent challenges for our world in this century are twofold:

- Combating global poverty, and
- Combating climate change.

Merely confronting the environmental and ecological challenge is not sufficient to achieve sustainability on earth. We must at the same time address the equally urgent problem of global poverty.

I am sure there will be many learned papers on the role of engineers in confronting the environmental and ecological challenges. I would therefore like to address the role of engineers and engineering in the economic and social uplift of the human condition, starting with the achievement of the UN Millennium Development Goals (MDGs) by all developing countries in 2015.

THE WORLD TODAY

By the turn of last century, world population has exceeded 6.0 billion that can roughly be divided into three classes:

- The rich (0.8 billion),
- The transitional (1.2 billion), and
- The poor (4.0 billion).

Based on the criterion of GDP, the classes of population are segregated as (a) rich, who have per capita income greater than $16000, (b) transitional, $ 4000-16000 and (c) poor, have less than $ 4000, respectively.

The rich have nine times wealth, eight times energy consumption and carbon emission compared to the poor. 20% of the world's richest people account for 86% of world consumption of energy and materials, whereas the poor account for only 1.3%. Moreover, out of total population —

- 1.3 billion live in abject poverty, subsisting on a daily income of less than US $1.00,
- 3.0 billion have a daily income of less than US$ 2.00,
- 800.0 million suffer from food insecurity,
- 50.0 million are HIV positive,
- 1.0 billion suffer from water scarcity, and
- 2.0 billion have no access to commercial energy.

Yet there has been much betterment of the human condition since the second half of the 20th century. According to Professor William Clark of Harvard:

- Life expectancy at birth goes up from 50 to 64 years
- Infant mortality come down from 13% to 6%
- Access to safe drinking water increased from 35% to 65%
- Literacy rate rises from 50% to 70%
- GDP/cap (developing only): US$ 900 ® $ 2900
- above 3 billion people with improved living standards.

It has been estimated that the world population will increase to 9.5 billion by 2050. Since the developed world's population is declining, all the increase will be in developing countries and principally in their urban centres. This will immensely aggravate the global sustainability challenge.

Undoubtedly science, engineering and technology (SET) is a significant contributing factor to widen the chasm between the rich and the poor on this earth. In this process, SET has also caused much environmental and ecological damage. SET must now reverse its role in the profligate use of the earth's limited resources to become a crucial part of humankind's march to sustainability.

THE UN MILLENNIUM DECLARATION AND THE UN MILLENNIUM PROJECT

Former UN Secretary-General, Kofi Annan realised that the urgent problems confronting the world at the dawn of the 21st Century, namely poverty, hunger, diseases, illiteracy, environmental degradation etc, could only be solved by collective global political will and resources. During the United Nations Millennium General Assembly in September 2000, the world leaders adopted the UN Millennium Declaration, committing their nations to stronger global efforts to alleviate poverty, improve health and promote peace, human rights and environmental sustainability. The Millennium Development Goals (MDGs) that emerged from the declaration are specific with measurable targets and timeline of 2015.

Unfortunately the global development agenda was sidetracked by the attacks on the World Trade Centre, New York and the Pentagon, Washington DC on September 11, 2001 and the subsequent wars in Afghanistan and Iraq.

To regain the development momentum, a UN initiative, the Millennium Project (UNMP), 2002-2006, then proceeded under project director, the special representative of UN Secretary-General, Professor Jeffrey Sachs of Columbia University. The purpose of UNMP with ten task forces was to propose the best strategies for developing countries to meet the millennium development goals, which are as follows.

Goal 1: Eradicate extreme poverty and hunger
Goal 2: Achieve universal primary education
Goal 3: Promote gender equality and empower women
Goal 4: Reduce child mortality
Goal 5: Improve maternal health
Goal 6: Combat HIV/AIDS, malaria and other diseases
Goal 7: Ensure environmental sustainability
Goal 8: Develop a global partnership for development

Correspondingly, the 10 MP Task Forces are constituted as follows:

Task Force 1 Poverty and economic growth
Task Force 2 Hunger
Task Force 3 Education and gender equality
Task Force 4 Child health and maternal health
Task Force 5 Expanding access to essential medicines
Task Force 6 Environmental sustainability
Task Force 7 Water and sanitation
Task Force 8 Improving the lives of slum dwellers
Task Force 9 Trade and finance
Task Force 10 Science, technology and innovation

UN MP ‘SCIENCE, TECHNOLOGY AND INNOVATION’ TASK FORCE

I was appointed as the president of the World Federation of Engineering Organisations (WFEO), together with Professor Calestous Juma of Harvard University, the Co-chair of the UN Millennium Project "Science, Technology and Innovation" (STI) Task Force.

In our report ‘Innovation: Applying Knowledge in Development’ issued in January 2005, the STI Task Force emphasizes the following areas of focus for developing countries.

• Improving the STI policy environment, including STI advice mechanism, technology management training for top policy makers in government, industry and civil society.

• Building STI human capacities, including strengthening STI educational institutions and reorienting the role of universities in development, graduating job creators rather than job seekers.

• Promoting entrepreneurial and innovation activities, with incentives for enterprise development, industrial extension services, government technology procurement, and venture capital market.

• Investing in research and development, building scientific and technological capabilities, supporting under-funded research in design and innovation including research in manufacturing and product marketing.

• Technology foresight for developing countries to find niches in global production chains.

• Forging regional and international STI partnerships.

It is to be noted that the STI Task Force study report is very much orientated away from the supply side of science toward the demand side of engineering, technology and innovation that is vital for employment creation and wealth creation in the developing world.

Our Task Force has documented many success stories and best practices in development in its study report. By the successful development processes adopted in Asia Pacific and SE Asia,our Task Force is convinced by the fact that, millennium development goals (MDGs) for least developed countries to lift themselves out of poverty and achieve by 2015, requires

• Basic infrastructure, ie, roads, schools, water, sanitation, irrigation, clinics, telecommunications, energy etc.

• Basic industries, namely small and medium enterprises (SMEs) for supply of goods and services to agricultural and natural resources exploitation industries. This means indigenous operational, repair and maintenance expertise and a pool of local engineers and technicians.

Without the Science Engineering and Technology (SET) base, especially the engineering and technology, indigenous industries cannot upscale, uplift economy and as a result foreign direct investment (FDI) will not come.

I am very much pleased that there is now almost universal recognition that infrastructure is essential for development. However, in the nineties to the turn of this century, infrastructure was a dirty word for World Bank, other development banks and also for the donor community. This was due to the decades of failed massive investments in mega projects that were inappropriate for the developing world and beggared further the already debt-ridden countries. To top it all, World Bank released the damning ‘World Report on Large Dams’ that set back hydropower development from a renewable source all over the world, perhaps with the exception of China. It was quite a struggle for me to push the infrastructure for development agenda in the UN Millennium Project.

BALANCING SCIENCE, TECHNOLOGY AND INNOVATION IN DEVELOPING COUNTRIES

In my discourses with the global SET Community, I always pose the question: Is it within the realm of science to build basic infrastructure and to develop the indigenous SMEs or is it much more within the realm of engineering, technology and indigenous innovation? In this audience of engineers, the answer is clearly the latter.

Yet, there exists an almost universal misconception that the necessary path for economic development in developing countries is obtained through greater emphasis and investment in science and scientific research. This view has consistently been championed by the development banks and the scientific communities in developing countries themselves. Postgraduate research departments of universities and basic scientific research institutes have been set up prematurely in less developed countries with their graduates and researchers finding no local gainful employment and migrating to the developed world, aggravating the brain drain.

Policy makers in inter-governmental organisations like the UN, national governments, and the scientific and academic communities in developing countries, must realize that scientific knowledge per se does not create wealth and employment. It is the application and commercialization of knowledge, scientific or otherwise, into useful devices, installations, services and systems through engineering and technological innovation that create wealth and employment. Therefore, there must be much more balanced resource allocation between science, engineering and technology in line with national needs.

I frequently appeal to my scientific friends to play fair to engineers. They should not continue to claim credit for engineering achievements. As of now, when a spaceship is successfully launched into orbit, it is a scientific achievement. When it explodes in flight, it is an engineering failure!

BARRIERS TO DEVELOPMENT IN DEVELOPING WORLD

Science, Engineering and Technology (SET) Brain Drain

Currently, there is a disturbing worldwide trend that enrolment in engineering courses in universities is declining. This has been particularly evident in developed countries with the related phenomenon of closure of engineering departments in universities and institutions of higher learning. The allure of great and imminent wealth in soft engineering like ICT is too enticing. As a result, developed countries have been exercising the prerogative of the ‘rich’ by recruiting scientists, engineers and technologists from the developing countries.

Most developing countries thus suffer on three counts.

• First, they do not produce enough scientists, engineers and technologists for their own need as their education and training infrastructure is inadequate to cope with the growing demand.

• Secondly, they expend scarce hard foreign currency in sending their students for expensive SET courses in developed countries.

• Thirdly, there is the constant SET drain, usually the best and the brightest, to the developed countries.

The solution for the developing world cannot be from the north back to the south. Unless and until economic conditions have become conducive, most efforts by developing countries to entice back their professional diaspora have been costly failures.

In my opinion, the redress must be through brain gain from other developing countries that produce large number of SET graduates such as China and India. Taking engineering as an example, there are more than 1.0 million engineering students in universities in China with some 400,000 graduating as engineers each year. Similar statistics also have been applied in India. To increase this number by 10%, would not strain the engineering educational resources of China and India but would be of great help for other developing countries. When the engineering qualifications from the above-mentioned countries are accepted first regionally and then worldwide, these countries will provide accessible and affordable engineering education and training facilities for students from other developing countries. It is thus very much a win-win situation for the whole developing world.

However, the barriers against mutual accreditation of qualifications and certification of professional experience are much higher between developing countries. Such accreditation and certification are squarely within the purview of government. This has been the case in the Association of South-east Asian Nations (ASEAN). Through the combined efforts of the national institutions of engineers in ASEAN in the last decade, progress has at last been achieved. The ASEAN Mutual Recognition Agreement (MRA) for engineering services was ratified by the ASEAN Ministers of Trade and Industry in December 2005. The ASEAN Charter was signed by all member governments at the ASEAN Summit in Singapore, November 2007. ASEAN is truly a legal regional entity. The ASEAN Secretary-General has recently agreed to accept the ASEAN Engineers Register (AER) of the ASEAN Federation of Engineering Organisations (AFEO) as the equivalent of the official ASEAN Chartered Professional Engineers Register under the MRA. The MRA implementation in ASEAN member countries is expected to be greatly facilitated by the national member institutions/societies of engineers of AFEO. Under the ASEAN political umbrella, there is every expectation that implementation of the ASEAN MRA will soon lead to a genuine mobility of professional engineers in ASEAN. It is to be hoped that the ASEAN MRA can be extended to embrace China and India through the political framework of 'ASEAN+China' and 'ASEAN+India'. The Institution of Engineers (India), being the largest professional body, can play a vital role in making the concept of brain gain a reality.

Dearth of SET Human Resources and Institutional Capacity

In developing countries besides brain drain, there is a desperate shortage of infrastructure implementation capacity, both human resource and institutional. Due to my work in UN MP, I was appointed in January 2005 by His Excellency M Kibaki, the President of Kenya, to the top level development think-tank, the National Economic and Social Council (NESC) of Kenya that is chaired by the President himself. I was the cochair of NESC Infrastructure Committee. In Kenya, there was a severe drought in the year 2004 and 2005, yet half of the annual financial allocation for the priority implementation of water storage for irrigation projects was returned to the treasury unspent. I advocated in NESC that the critical capacity constraint in infrastructure implementation could be relieved by the employment of military engineering divisions and units. In any developing country, the military engineering divisions and units are amongst the best equipped for basic infrastructure rehabilitation. This slightly differs in their conventional role in disaster relief in the construction of access roads, bridges, jetties, temporary shelters, provision of safe drinking water and electricity supply and the implementation of basic infrastructure in remote and rural areas. Yet, such invaluable capacity remains idle in a sea of need.

Military engineers predate civilian engineers, where as the term 'civil engineer' was used to differentiate it from 'military engineer'. In history, Caesar's legions built roads, aqueducts, baths and sewers. The mighty Mongol hordes of Genghis Khan relied very much on their innovative military engineers to extend the reach of empire. In more recent decades, military engineering units in China, Taiwan and Korea, have contributed significantly to the construction of much needed infrastructure and laid the foundation of their bludgeoning construction industry.

In the recent Sichuan Earthquake in China, the military engineering divisions have done an outstanding job in disaster relief. It has come to notice that in the critical work of reducing the water build-up behind the land-slide blocked rivers, the 'An Ning Group Corporation' of Fukien Province was a leader, which was then found a part of the Chinese military engineering corps.

With the tacit understanding of the Kenyan government, I contacted my good friend, General (retired) Hank Hatch, the former commander of the US Army Corps of Engineers (USACE) and then Chair of the International Committee of the American Society of Civil Engineers (ASCE) to interest USACE to mentor the formation of a construction corporation of military engineers in Kenya and USACE, which was recognised as the outstanding military engineering corps/corporation in the world. I shuttled between Nairobi and Washington DC several times.

As USACE was part and parcel of the US military subject to the policy dictates of the US Department of Defence, then under Donald Rumsfeld, progress was very slow as its policy towards Africa was not to help the country for development but in anti-terrorism etc. In other words, Africa should follow the US agenda. Kenya and other African nations have been most reluctant to bow to US pressure. The US Africa Command is the most recent example. Meanwhile, Kenyan government has been advised to engage their military engineering units for infrastructure projects. Kenyan military engineering units are now being engaged not only in water storage projects but also in rural road projects as well.

I am persisting in my recommendation to NESC and USACE to get together to help to create a Kenyan engineering corporation of military engineers. The Obama presidency with his deep roots in Kenya may just be the needed catalyst.

Historically, Indians played a significant role in the social and economic development of Kenya, starting with railroad construction. I therefore appeal to Indian engineers and the engineering community to assist in the capacity building of infrastructure implementation in Kenya. In the context of The Institution of Engineers (India), I would, therefore, suggest that a good start can be made by the engagement of the Engineering Staff College of India in Hyderabad. I am confident that the Hon Raila Odinga, Prime Minister of Kenya, being a mechanical engineer, would welcome such an initiative.

SOUTH-SOUTH COOPERATION IN STI

In my interaction with African policy makers and SET leaders, I have been struck by the widespread despondency in Africa that the SET chasm between the developed countries in North America and Europe and African countries is too wide to them to bridge. I have urged Africa to look instead to Asia Pacific and South East Asia where macroeconomic stability, self-reliance, hard work, thrift and investment in education have transformed the economic landscape in the short span of three decades.

I have as a consequence been advocating genuine South-South cooperation with high and middle income developing countries like Malaysia, China, India, Brazil, Mexico and others as donors in the 'Science, Technology and Innovation (STI) for MDG' process for Africa. The 'Look East and Look South' orientation is a central plank of my continuing advocacy for Africa. In this process, Malaysia has been playing a key role.

International Science, Technology and Innovation Centre for South- South Cooperation under the Auspices of UNESCO

In China and +G77 Summit Meeting at Doha, UNESCO was urged to devote more attention to engineering, technology and innovation to assist economic development in the developing countries in 2005. UNESCO invited Malaysian Minister of Science, Technology and Innovation, Dato Dr Jamaludin Jarjis, to host the International Science, Technology and Innovation Centre for South-South Cooperation (ISTIC), at Malaysia. The Centre was approved by the UNESCO General Conference, October, 2007. ISTIC was launched in Kuala Lumpur in May 2008. The objectives of ISTIC are as follows.

- Facilitating the integration of a development al approach into national science and technology and innovation policies,
- Capacity building in science and technology through providing policy advice and exchange of experience and best practices,
- Creating a problem solving network of centres of excellence in developing countries, and
- Supporting exchange of students, researchers, scientists and technologists among the developing countries.

My priority as the Chairman of ISTIC governing board is to establish the troika of Government, Industry and Academia in Southern countries. This task will be very difficult in the prevailing climate of global advocacy of small government, so as to let the market have a free rein. I repeatedly argue that economic development of China, Korea, Malaysia, Singapore and Taiwan was led by their 'autocratic' political leaders like Deng Xiao Ping, General Pak Chung Hee, Dr Mahathir Mohamad, Lee Kuan Yew and General Chiang Ching Kuo respectively. If the private sector is left alone to maximise their bottom line, the world will suffer more 'the tragedy of the common' like fishing the oceans to depletion and global warming by excessive carbon emission. I trust the current global financial tsunami, that is triggered by the excessive greed of Wall Street and aided and abetted by STI in the guise of complex financial computer software and the global spread of internet, will make the developing world value the indispensable role of government in assuring the 'Asian Values' of self-reliance, hard work, thrift and investment in education.

ISTIC must therefore look to all the developing countries to commit themselves to cooperation in STI for economic and social development, beginning with achieving the MDGs. With STI giants like Brazil, China, India and Mexico leading the way, I firmly believe this is achievable.

EDUCATION AND DEVELOPMENT

Economic growth in developing countries is predicted on indigenous human resources, institutional and enterprise-related capacity building, especially in STI. Since institutions and enterprises are run by human beings, it all boils down to human resources capacity building. Priority must therefore be focused on education.

University

Universities in developing countries must act as the fountains of knowledge for social and economic development. Universities must reorient themselves to serve the development needs of their region and their nation. The graduates must be cross-disciplinary in their training with good understanding of the convergence between physical and social sciences, engineering and technology, economics and finance, development policy, and social and cultural perspective in development. Turning out innovative and entrepreneurial graduates must be the mission of the universities in developing countries.

The conventional staffing of universities in developing countries with PhD is not the route to innovation and competitiveness for the national economy. Academics should not be recruited on PhD degree, research experience and publications only. They must have working experience in industry and in the marketplace if they are to understand the needs of the economy and the community. I would strongly advocate that successful candidates as academics should have demonstrated some prior and continuing involvement in community services, especially MDG-related.

Universities in developing countries must be graduating job creators rather than job seekers. They should establish undergraduate incubators that assist students to venture into knowledge based enterprises suited to the needs of economy. Such undergraduate enterprises will attract industry participation as they are the most fertile recruiting ground for industry. If they succeed beyond graduation, they will create jobs and add to the successful knowledge-based enterprises in the country. Even if they fail, the graduates would have been well schooled in the hard knocks of business life and well adapted to the needs of the industry.

R&D in developing countries should be focused and applied to enhance the indigenous advantages in niche areas. For example, R&D in rubber, oil palm and forestry technology in Malaysia has added value to the global production chain and contributed to the economic uplift of Malaysia.

Universities in the developing world benchmark themselves against the best in the developed world. There is also the constant advocacy to turn vocational institutions into polytechnics, polytechnics into technical universities, technical universities into research universities and research universities to be ranked amongst the top research universities in the world. This is the great developmental disconnect between the educated elite and the stark reality of joblessness for post-graduate researchers and graduates. I would like to suggest that instead, every developing country benchmarks its universities against their relevance and success in meeting the critical development challenges of the nation. Such 'Fit for Purpose' measurements will be much more meaningful for employment creation and economic uplift of the developing world. There must of course be meaningful financial encouragement and social recognition for such community based and development focused universities and their academic staff.

University dons in developing countries tend to promote cutting edge research into ICT, nanotechnology, biotechnology etc when neither governments nor industries have the resources to take the fruits (if any) of research to the market. They should instead emulate for instance the Industrial Technology Research Institute (ITRI) in the Sinchu High Technology Park, Taipei, Taiwan. Besides applying nanotechnology in enhancing the products in computer technology and microelectronics, ITRI assists the SMEs in applying nanotechnology in value-addition of such products in textiles, paints, car polishes and waxes etc.

International Commission on Education for Sustainable Development Practice (ICESDP)

The International Commission on Education for Sustainable Development Practice (ICESDP) was set up by Jeffrey Sachs and John McArthur of the Earth Institute in 2007 with funding from the McArthur Foundation. I was a member of ICESDP representing engineering in general and the ASEAN Academy of Engineering and

Technology in particular. The Commission began with the premise that current training for development practitioners does not sufficiently integrate science, engineering, and policy with economics and finance. The Commission spent nearly 18 months working to identify the gaps in current training for the development of professionals and to recommend improvements. After an examination of current development training worldwide and consultations with stakeholders and experts on five continents, the Commission presents its report, that was launched in New York on October 10, 2008, with a series of key recommendations.

These include the creation of new, 27-month Master's in Development Practice (MDP) programs at universities worldwide. The MDP degree will combine classroom study in the natural and social sciences, public health, engineering, and management with two summers of field training to educate a new generation of development practitioners prepared to tackle the challenges of poverty across complex fields. ICESDP believe that a sound knowledge of engineering is a pre-requisite for practitioners who must understand how to help countries to develop better infrastructure, which is one of the key building blocks for sustainable development.

Universities in developed and developing countries are encouraged to partner to offer the full curriculum. With support from the MacArthur Foundation, the first such program will be offered by Columbia University's Earth Institute in cooperation with the School of International and Public Affairs in the fall of 2009. MacArthur will support up to 12 universities to launch similar programs in the next three years. The MacArthur Foundation has also helped to establish a Global MDP Program Secretariat at Columbia's Earth Institute to serve as the umbrella organization overseeing all MDP programs and activities worldwide. One can visit the ICESDP secretariat at http://mdp.ei.columbia.edu/ for free download of the report, its executive summary and other background information.

In a letter introducing the ICESDP report for the WFEO website, Jonathan Fanton, President, McArthur Foundation and the two ICESDP co-chair send the following message to engineers worldwide:

‘We look forward to the advancement of understanding across fields to help aspiring practitioners tackle some of the greatest challenges of our century, thus helping to improve the quality of life for millions who have not yet seen the benefits of economic development, and we hope that current and future leaders in the field of engineering will help us to take up this challenge.’

In my opinion, this is a groundbreaking initiative in education for development. The ICESDP programs will infuse the practice of engineering in infrastructure, energy, water and sanitation, health care, irrigation and food production, biodiversity management into the practice of sustainable development. I have urged the national and international members of WFEO, WFEO Standing Technical Committees on Education and Training, Engineering and the Environment, Information and Communication, Capacity Building and Technology Transfer (COMTECH) to interact with ICESDP and offer constructive suggestions to enhance the ICESDP programs. I have also requested them to interact with their universities to explore the possibilities of becoming partners in the global ICESDP network and become active partners in the ICESDP Master's degree program in development practice.

I am very pleased to have connected with the Engineering Staff College of India of IEI in Hyderabad to the ICESDP global network. For any other interested Indian institutions of higher learning, they may contact ICESDP regional contact for the Indian subcontinent, Dr Rajendra Pachauri of TERI University.

LIGHTING THE WAY: TOWARDS A SUSTAINABLE ENERGY FUTURE

The common denomination underlining global poverty eradication and climate change is energy, the lack of it for economic development on the one hand and its excessive utilization on the other.

As an energy practitioner through all of my professional life and in the context of this Congress, I will be amiss if I do not introduce you to the energy study report ‘Lighting the Way: Toward the Sustainable Energy Future’ of the InterAcademy Council (IAC) held on October 2007. IAC was set up by 95 national academies of sciences under the umbrella of InterAcademy Panel (IAP) to produce reports on scientific, technological, and health issues related to the great global challenges of our time, providing knowledge and advice to national governments and international organizations. The first two of IAC study reports were done at the request of the then UN Secretary-General, Kofi Annan. IAC study reports are regarded as evidence-based, transparent and unbiased. They are not funded nor influenced by vested interest groups, be they public sector, private sector and single-agenda NGOs. This is especially important in tackling the complex issues surrounding energy. I was a founder Board Member of IAC during 2001-2005 representing the Academy of Sciences Malaysia. Earlier this year, I was appointed as Special Advisor on Sustainable Energy to IAC Co-Chair with the task to coordinate the organisation of regional energy workshops/conferences to promote the recommendations of the IAC energy study report.

The IAC study report is comprehensive in coverage from an overview of the energy sustainability challenges through detailed examination of energy supply and energy demand, the role of science and technology in energy research and development of the governmental role. It emphasizes a holistic approach required to solve the global energy problem, focusing upon :

• People: intergovernmental organisations, national governments, energy industries, academia and NGOs;

• Conservation: maximize energy efficiency and energy use;

• New sources of clean energy.

Energy demand is rising, particularly in fast developing economies like India and China. However, the current global financial tsunami will make capital for energy projects in developing countries in extremely short supply. Even when available, it will carry a high interest charge. It will inevitably enhance coal as the energy source as it is plentiful, internationally tradable and its technologies for energy production are mature. This will however have adverse carbon emission consequences.

In my opinion, developing countries must focus their efforts on energy conservation and energy efficiency to counteract the above. Cities must be the prime focus, as cities have the most energy intensive footprints. They house half of world population of 6.3 billion and will house the projected 3.0 billion more by 2050, mainly in developing countries. I urge developing countries to emulate the examples of US cities, say in California, in urban planning, legislation, transportation and retrofit of buildings and facilities in reducing their carbon and pollution footprints.

Ultimately, the solution to climate change must rest in the hands of the developed countries that consume more than 80% of the world's energy and contribute to the similar percentage in carbon emission. The argument ‘More energy consumption is necessary to assure prosperity in developed countries’ is not valid. There are developed countries in Europe with low annual electricity consumption per capita and high human development indices. Human development index is a measure of the well being of a nation, being derived from factors like life expectancy, level of education and GDP per capita.

SUSTAINABLE CONSUMPTION

The critical problem facing the developing world is creation of employment and wealth. In this endeavour, the developing world would need to increase consumption of materials and energy. For this to happen without damaging the world eco-system, the developed world must practise sustainable consumption.

However, sustainable consumption has seldom been on the global development agenda. It is not favoured because it is perceived to threaten competitiveness and profitability. Whilst the unbridled consumption of the developed world is damaging in itself, its lifestyles have unfortunately become models for consumers in the more affluent developing countries. If the global consumption of energy and materials were to become as intensive as that of the average American, worldwide usage would increase several-fold and environmental damage through climate warming would rise similarly.

In order to realise sustainable consumption, drastic changes in life-styles will be necessary in the developed world and in the higher income group of developing countries. There would need for resolute political and societal will. The world could well learn from China in her latest policy of scientific government and development. Whilst emphasizing that the welfare of human beings is central, it stresses upon conservation of natural resources, minimisation of waste and the harmonisation of human development with the environment towards achieving the national aspiration of a harmonious society of middle income families.

CONCLUSION

Instead of striving to stay ahead in competitiveness, exhausting global resources in energy and materials, polluting the environment and endangering the very survival of our planet through global warming, we must work urgently together to assure the quality of life rather than the quantity of living.

The Forty-fourth Nidhu Bhushan Memorial Lecture was delivered during the Twenty-fourth Indian Engineering Congress, Mangalore, December 10-13, 2009

New Energy Efficiency Standards for Three-phase Induction Motors in Korea

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Energy efficient electric motors generally represent one of the largest opportunities for cost-effective electricity savings all over the world. In Korea, since July 2008, three-phase induction motors manufactured or imported in the country must comply with mandatory minimum energy performance standards (MEPS) as the new energy standard. MEPS means the mandatory policy to control the spread of the low efficiency products and promote the manufacturers' technical development by setting up and controlling the minimum required efficiency standard. It is decided that three-phase induction motors over 37kW should comply with the MEPS from 2008 firstly and those under 37kW from 2010. In this article, MEPS of Korea including the standard test method is introduced.

INTRODUCTION

In general, about 70% of the electrical energy consumed by industry is used by electric motor systems and the vast majority of these are induction motors. They are used both in industrial and commercial fields in a wide range of applications, such as, fans, compressors, pumps, conveyor, transport, home appliances and office equipment[1]. Energy efficient electric motors represent one of the largest opportunities for cost-effective electric savings and the action plans for the reduction of the greenhouse gas emission. Accordingly, law or protocol, such as, Energy Policy Act (EPAct) and the agreement between the European Union and the European Committee of Manufacturers of Electrical Machines and Power Electronics (CEMEP) Committee, Europe, have been announced in the USA, Canada and Europe[2].

In Korea, the government has carried out the voluntary policies since 1996 and has offered rebates for high efficiency motors since 2002, but the market share of high efficiency motor was no more than 10%. Therefore, it was decided by the government in 2004 that MEPS for three-phase induction motors would be enforced[3] from 2008. MEPS means the mandatory policy to control the spread of the low efficiency products and promote the manufacturers' technical development by setting up and controlling the minimum required efficiency standard. The MEPS covers three-phase ac squirrel-cage induction motors from 0.75kW to 200kW with the low voltage.

High efficiency induction motor is more efficient than the standard motor by 4% to 5%. The MEPS has been discussed with the relevant industries to determine the starting time, the scope of induction motors and the test methods for the enforcement from 2008. It was decided that three-phase induction motors over 37kW should comply with the MEPS from 2008 firstly and those under 37kW from 2010. The goal of this policy is to increase the market share of high efficiency induction motors from 10% (2005) to 70% by 2014 and the money saved is expected to be one billion dollars. In this paper, the plan and the effects of MEPS in Korea, have been introduced.

POLICY FOR HIGH EFFICIENCY INDUCTION MOTORS IN KOREA

Consumption of Electric Power in Korea

The consumption of electrical power in Korea is growing more than 5% every year (Table 1), and three-phase induction motors account for above 40% of electricity consumption as shown in Table 2.

Therefore, the development of the high efficiency motors has been taken up to save the electrical power consumption.

Market Share of High Efficiency Induction Motors

Three phase induction motors are divided into three groups by the efficiency level in Korea as shown in Figure 1. The first group is the general efficiency motor, the second is the high efficiency motor and the third is the premium high efficiency motor. The efficiency of high efficiency motor is 3% to 5% higher than that of the general efficiency motor. Since 2002, Korean government has offered rebates on the high efficiency motor to replace the general efficiency motor as shown in Table 3.

Table 1 Annual power consumption in Korea

Year	2002	2003	2004	2005
Power consumption, Gwh	278,451	293,599	312,096	332,413
Increasing rate, %	7.4	5.2	5.9	6.1

Table 2 Power consumption of three phase induction motors (2002)

	Power, GWh	GDP, million US $
Total amount	278,451	17,530 (100%)
Amount of three phase induction motor	111,830	7,010 (40%)

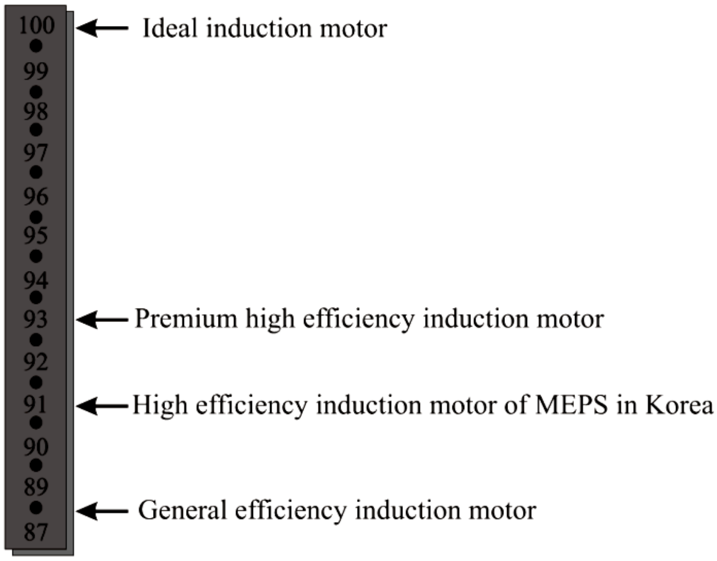

Figure 1 Efficiencies induction motors (4 pole, 15 kW)

Table 3 Rebate for high efficiency motors

Year	2003	2004	2005
Quantity(set)	7,229	6,687	8,743
Capacity, kW	119,255	99,077	155,027
Rebate, US$	834,281	749,482	1,320,279
Rebate for end user	198 US$/kW(power saving)		
Rebate for manufacturer	40 US$/kW(power saving)		

However, its market share is about 10% in 2005 as shown in Figure 2. Therefore, the MEPS is carried out for the purpose of increasing the market share of this high efficiency motor in Korea in 2008. The efficiency of premium high efficiency motor is 4% to 5% higher than that of the high efficiency motor, but its present market share is very small. However, as an important method of energy savings, the government is preparing the development of the premium high efficiency motor with the cooperation of the research institutes and manufacturers. In addition to that, the certification and rebate for premium high efficiency motor is planned to be carried out from 2008 in Korea.

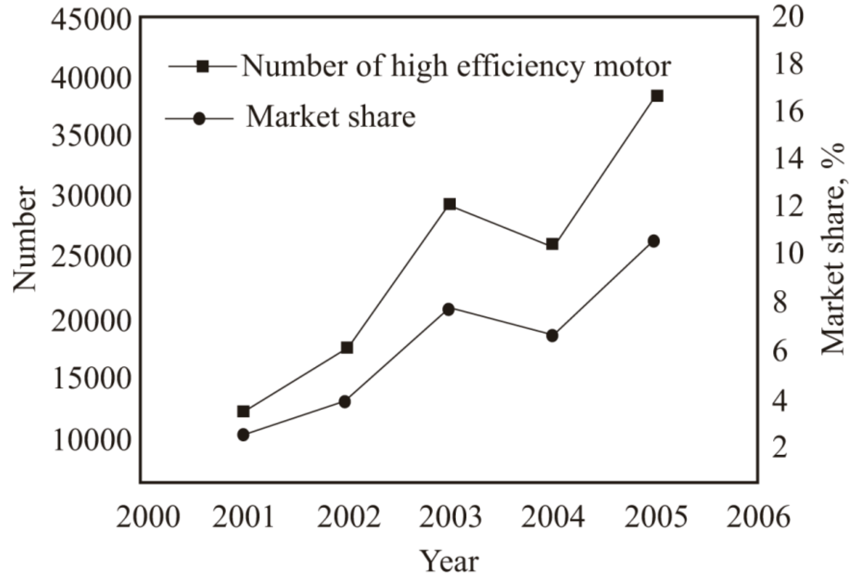

Figure 2 Market share of high efficiency induction motor

Table 4 The scope of the induction motors in the Korea's MEPS

General purpose	**Foot mounted or flange**
Design A or B	Operating below 600V
KS-C 4202 frame	Open and enclosed
Polyphase	2, 4 and 6 pole design
Constant 60 Hz power	Squirrel cage induction motor
Single speed	0.75kW to 200kW

MEPS IN KOREA

Scope

Table 4 shows the scope of the induction motors in the Korea's MEPS. The five categories of EPAct of USA for the detailed scope of three-phase induction motors have been referred. Category I and II of EPAct are the scope of MEPS. Category I means the general purpose motors and Category II means the definite purpose motors that can be used in most general purpose applications. In addition to Category I and II, pump motor and geared motor are also included in the scope of MEPS.

Efficiency Level

Table 5 shows the efficiency levels of ODP and TEFC motors, as per Korea Industrial Standard C 4202 for low-voltage three-phase squirrel-cage induction motors[4].

Testing Method

There are various test methods for evaluating the efficiency of the motor, such as, IEC 60034-2, IEEE 112, CSA 390 etc[5-11]. Table 6 shows an example of the comparison of motor efficiency test methods. For the verification of motor efficiency, IEC 61972 has been adopted where the motor is loaded and the power is directly measured[12]. There are two methods in IEC 61972 for determining losses and efficiency of three-phase cage induction motors, and includes an improved measurement of stray load loss. The first method is for motors tested by using a torque measurement with stray load loss derived from the measurements. The second method is for motor tested without torque measurement, with assigned stray load loss. The MEPS selects the first method for measurement of efficiency and to achieve this measurement, an accurate mechanical output must be measured at the shaft of the motor.

Table 5 Efficiency levels of motors

Rated output, kW	Minimum efficiency level, %					
	ODP			TEFC		
	2-Pole	4-Pole	6-Pole	2-Pole	4-Pole	6-Pole
0.75	82.5	82.5	80.0	81.6	82.5	82.0
1.5	84.0	84.0	85.5	84.0	84.0	86.5
2.2	84.0	86.5	86.5	85.5	87.5	87.5
3.7	85.5	87.5	87.5	87.5	87.5	87.5
5.5	87.5	88.5	88.5	88.5	89.5	89.5
7.5	88.5	89.5	90.2	89.5	89.5	89.5
11	89.5	91.0	90.2	90.2	91.0	90.2
15	90.2	91.0	91.0	90.2	91.0	90.2
18.5	91.0	91.7	91.7	91.0	92.4	91.7
22	91.0	92.4	92.4	91.0	92.4	91.7
30	91.7	93.0	93.0	91.7	93.0	93.0
37	92.4	93.0	93.0	92.4	93.0	93.0
45	93.0	93.6	93.6	93.0	93.6	93.6
55	93.0	94.1	93.6	93.0	94.1	93.6
75	93.0	94.1	94.1	93.6	94.5	94.1
90	93.6	94.5	94.1	94.5	94.5	94.1
110	93.6	95.0	94.5	94.5	95.0	95.0
132	93.6	95.0	94.5	94.5	95.0	95.0
160	94.5	95.0	94.5	95.0	95.0	95.0
200	94.5	95.0	–	95.0	95.0	–

Table 6 Comparison of motor efficiency test methods

Motor power, kW	Motor efficiency test methods		
	IEEE 112B	IEC 34-2	JEC-37
0.75	76.8	78.8	79.6
1.5	81.1	83.1	83.8
2.2	81.4	83.4	84.1
3.7	83.9	85.9	86.5
5.5	84.8	86.8	87.3
7.5	85.6	87.6	88.1
11	87.4	89.4	89.9
15	88.3	90.3	90.7
18.5	88.9	90.4	90.8
22	89.8	91.3	91.7
30	90.4	91.9	92.3
37	91	92	92.4
45	91.5	92.5	92.8
55	92	93	93.3
75	92	93	93.3
95	92.2	92.7	93
110	92.8	93.3	93.6
150	93.8	94.3	94.6

IEC 61972 is also equivalent to IEEE 112 (method B) and CSA 390 (method 1). These test methods include an improved measurement of stray load losses. An accurate mechanical output must be measured at the shaft of the machine for these tests.

IEEE 112 is divided to ten test methods and includes actual loading method and equivalent circuit method. The stray load loss is determined by two methods of indirect and direct method. IEEE 112 method B is used the indirect method for measurement of stray load loss.

CSA 390 is also a testing method for three-phase induction motors which was published in 1998. It is divided to three test methods. The method 1 is input-output method with indirect measurement of the stray load loss and direct measurement of the stator winding, rotor winding, core, and windage-friction losses.

IMPACTS OF MEPS

Korean government had carried out the voluntary policies for the promotion of high efficiency motor since 1993 and also offered rebates for upgrading to a high efficiency motor. However, the market share of high efficiency motor was no more than 10%. If MEPS would be enforced since 2008, it is expected that their market share increases to 70% (Figure 3). The energy saving money will be one billion dollars despite the cost of replacing the standard motor with the high efficiency motor. It is also expected to strengthen the technology of the manufacturers and accelerate the export to other countries.

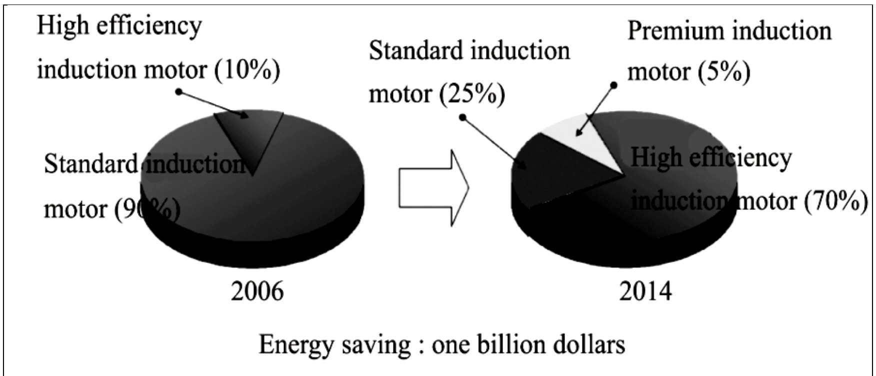

Figure 3 Motor distribution in Korean market

CONCLUSIONS

The Korean Government has made several policies including high efficiency motor certification and rebate for high efficiency motor to increase the use of the high efficiency motor in Korean market. To accelerate this activity, it will be better to enforce MEPS for the three-phase induction motors, the mandatory policy since 2008. The government also has plans to support the motor manufacturers with high efficiency technology and test facilities which are for the successful enforcement of MEPS. If the MEPS of Korea can be established stably, the energy saving is expected to be equal to over one billion dollars.

The government is also leading the development of the technology of premium high efficiency motor which has 4% to 5% higher efficiency than high efficiency motor, and plan to transfer the certification and the rebate from the high efficiency motor to premium high efficiency motor from 2008.

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Decisions and Their Implementation — Case Study — PRITHVI

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INTRODUCTION

Taking decisions and implementing them are essential in Projects. Decision making may be considered under six aspects :

1. History – Learn from it.

Available info/data – Study and Analyze.

Gaps in Knowledge / Technology – Identify and Remove.

2. Use intuition, anticipate emotional reactions of others, understand responses of persons not knowing your reasoning.

3. Look at bad points of decision, why it may not work. Eliminate, alter or make contingency plans.

4. Positive, optimist, helps progress in gloomy / difficult situations.

5. Creative solutions, futuristic thoughts.

6. Chairmen of Meetings, Boards have to take decision, when ideas are running dry, contingency plans are needed – Organize Tiger Teams, Process Control changes may be needed.

Examples are presented of these considerations.

HISTORY

Surface to Air Missiles: Air Force faced difficulty in keeping the missiles operational due to difficulty in getting spares. A Project was initiated by Air Force and approved by CCPA to establish and prove competence by indigenizing systems and flying the missile. Project was completed within time frame proving indigenous competence. Production was considered. However by that time it was felt that the missile would be retired shortly and need not be produced. This experience led to the following decisions.

Decision 1

• Make or buy recommendations. Users and DRDO to jointly evolve with firm commitments of quantity, time and cost for

(a) Development (b) Production (c) Operation and Maintenance

• Approval by CCPA

Decision 2

IGMDP (Integrated Guided Missile Development Programme) was sanctioned in 1983. This was based on detailed discussions between DRDO, users, industry, academia, government backed by political will – R Venkataraman (Raksha Mantri) and Smt Indira Gandhi (Prime Minister). Prithvi, Trishul, Akash, Nag, Agni (Technology Demonstrator) were part of IGMDP. Critical technologies were not available in India but the decision was – DO IT.

PRITHVI CONCEPT

Concept evolved by Missile Policy Committee (Users & DRDO) between 1975-80 for a Mobile Tactical Surface to Surface Missile for ARMY – 40 km to 150 km with TNT warhead. Competence Buildup Projects were taken up to remove gaps (1980-82) and were utilized in IGMDP with Phase 1 period of 12 years.

PRITHVI AIM AND PHILOSOPHY

A focused aim and philosophy were laid down by the Project Director.

Aim

Induct Reliable Surface to Surface Missile System with range of 40 km to 150 km and one tonne warhead into army within 12 years.

Philosophy

- Full user involvement
- Systems Engineering and Concurrency in Production
- Maximum Indigenous Components to Specific Standard

- QUALITY IS FREE

- Follow all Rules and Regulations, Codes /Standards.
- Genuine mistakes tolerated but hiding them - NO

Well meant advice was that this philosophy was utopian and the project will never take off. Many felt that the project had FUNNY GUYS.

USER REQUIREMENTAND REALISTIC ASSESSMENTS

The following actions were implemented :

• Detailed open discussion with user BEFORE drawing up requirements
• Formalized by Joint User-DRDO Committee
• Realistic time schedules and costs
• Activities for Deployment of System worked out in depth

- Design and Development
- Production Base
- Maintenance Facilities
- Product Support
- Training (operation / maintenance)
- Inspection

SYSTEMS ENGINEERING

Systems engineering transforms an operational need or concept / opportunity into a system description to support detail design. It should consider

- Environment
- Maintainability
- Life Time Cost
- Logistics
- Management Structure
- Disposal after Retirement

These formed the basis for developing an operational model which was the foundation for detailed design for the PRITHVI.

SCOPE OF SYSTEMS ENGINEERING (SE)

The scope of systems engineering covers the application of science and engineering to

(A) Transform Operational Needs into

— A quantification of system performance parameters required by the user and
— A system configuration through the use of an iterative process of definition, synthesis, analysis, design, test and evaluation.

(B) Integrate related technical parameters and ensure compatibility of all physical, functional and program interfaces in a manner that optimizes the total system definition and design.

(C) Integrate reliability, maintainability, safety, survivability, human engineering and other such factors into total engineering effort to meet cost, schedule, supportability, and technical performance objectives.

The sequence and feedback are indicated in Figure 1.

TECHNICAL STRATEGY

The technical strategy and systems engineering recommendations were based on a SWOT analysis of the areas indicated in Figure 2.

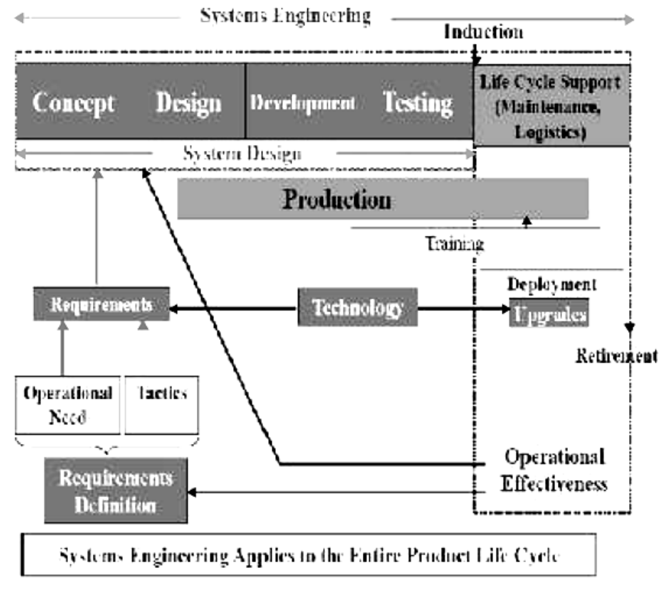


Figure 1 Scope of the systems engineers

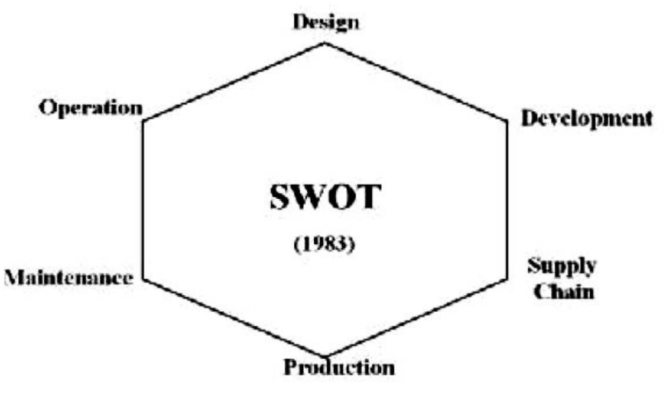


Figure 2 SWOT analysis

MAJOR SYSTEMS ENGINEERING DECISIONS IMPLEMENTED

The major systems engineering options and recommendations for Prithvi are summarized below. Based on these, decisions were taken and implemented.

1. Trajectory	Ballistic Ballistic / Adyn (Recommended)
2. Guidance	Explicit Implicit (Recommended)
3. Flight Control System	Analog Digital (Recommended)
4. Control Actuation	Pneumatic Hydraulic (Recommended)
5. Microprocessor	Motorola (Fixed Point) Intel (Floating Point (8086) (Recommended)

6. Flight Computer	Separate for Nav & Control / Guidance Single-Integrate Control – Nav- Guidance (Recommended)
7. Subsystem Flight Clearance	Acceptance Level Qualification Level – Clearance (Recommended) Acceptance Level – Flight (Recommended)
8. First Flight	Ballistic without INS and Guidance Full System with INS and Guidance (Recommended)
9. Components (for initial tests)	- Any - Only MIL SPEC - Standard to meet Environment (Recommended)
10. Auto Launch	- Hold points and sensors
11. Redundancy	- Launch Release Mechanism (4) } -On Board Computer - Engine Shut off (2) } -Launch Computer

SUPPLY CHAIN

Examples faced in supply chain historically are indicated. These strengthened the actions for quality and indigenous items.

1. Degradation of performance Willys Jeep at High Altitudes - 1960

2. Poor Quality

• Buldozer (Japan) Blade Bolts - 1961

• Stage Separation Bolt (HAL) - 1979

3. Restrictions

• Magnesium Plate - ISRO - 1975

• Mainframe Computer DRDL - 1980

4. Indigenous Availability of Aerospace Grade Materials / Components - 15%

5. Foreign system offers even if they did not meet the laid down user requirement.

ACTIONS / IMPLEMENTATION

1. Weldable Aluminum (Al Mg Si) to Aerospace grade was not indigenously available

- Sheets were developed by collaboration with BALCO. Special Spec drawn up with CRE (Materials) and Designers considering BALCO limitations.
- 1000 mm Rings – HAL (Foundry and Forge) developed the item in collaboration with private industry.

2. Magnesium plate was not produced in India and all enquiries to foreign firms went unanswered. Defence Metallurgical Research Laboratory (DMRL) developed the plate in collaboration with academia and both private and public industries.

3. Titanium Plate - The high pressure air bottle was specifically designed for fracture toughness of Ti plate realized at MIDHANI.

4. India's First Digital Flight Control System integrated with Strap Down Inertial Navigation and Guidance was developed for Prithvi by DRDL, rejecting foreign offers using older technology.

5 Actuators - A Foreign offer was NOT accepted, HAL (Lucknow) developed the item.

6. Servo-Valves - Foreign company withdrew from TOT agreement and production, technology was established by DRDL / RCI.

7. Quality - DTD&PAir, R&QA (DRDL / RCI) - Missile System Quality Assurance Agency

8. Design Audit - CEMILAC

COTS AND SCOTS

These were particularly envisaged for electronics.

COTS - Components Off The Shelf usage proposed in general

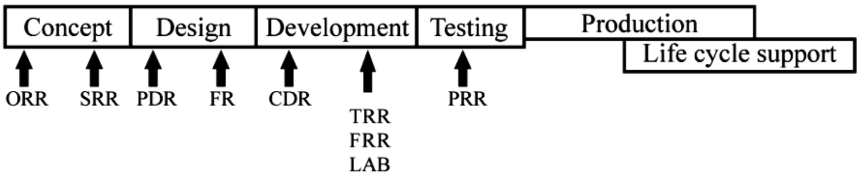
- Interpretation – any commercial component

SCOTS - Standard Components off The Shelf accepted by PRITHVI
- Group formed to attack Electrical / Electronic components in Prithvi LCSO (Electronics Components Standardization Organisation) BEL, HAL (Hyderabad), ECIL, MSQAA, Director (DRDL / RCI), eg: Connectors, Crystal Oscillators
- Minimum Standards for Missiles were established and augmentation of Test Facilities at CQAL to clear Components was sanctioned.

Designer - Choose a Component to a specific standard which will meet the sub-system qualification level.
- Qualify sub-system.
- Subsequent sub-systems to use components of SAME standard.
- Approved by Guided Missile Board-well before COTS fever in India.
- Indigenous manufacturers for 60% of Electronic System Components identified and cleared.

SYSTEM LIFE CYCLE: REVIEWS & TESTING

System Life Cycle & Testing were taken up in the sequence indicated below.



ORR - Operational Requirements Review
SRR - System Requirements Review
PDR - Preliminary Design Review
FR - Fabrication Review
CDR - Critical Design Review
TRR - Test Readiness Review
PRR - Production Readiness Review
FRR - Flight Readiness Review
LAB - Launch Authorization Board

TESTING AND DOCUMENTATION

- Levels
  - Configuration Item (CI)
  - Sub-system
  - System (deliverable)
- Types
  - Performance – Static
  - Safety
  - Qualification
  - Environmental AvP35
  - Flight tests using qualified sub-systems
  - Acceptance
    - Design Certification / Audit -CEMILAC - Design, Test, Qualification, Documents
    - User (Missile System Quality Assurance Agency)
- Review EHS (Environmental, Health, Safety) issues
- Develop user documentation
  - Operational
  - Maintenance

FLIGHT TESTING

Development - Less Warhead ITR

- Sea Range ITR
Navy

- Air and Marine Clearance People Evacuation - Initially

- ITR

- Warhead – Pokhran (Warhead Test Vehicle 1989)

- Ground (Vehicle)-VRDE Track

Location of Impact - Fluorescent Dye, GPS

No of Tests (Original) - 60

• Extensive telemetry introduced

• Review reduced no of Development tests to 30 (allowing for failures)

Flight Test - ANALYSIS - Flight Test - Sequence followed

• Actual Development Flight Tests - 15

• User Flight Trials 2 out of 3 should meet Min and Max Ranges (Jun 1994) (Army asked to chose (Range)

1. Impact on Land

• ITR - Wheeler Island (Impact) - 1994

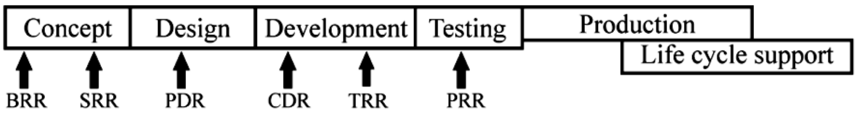
2. Max Range (Range Radar, Ship Radar, Fluorescent Dye, GPS)

FIRST FLIGHT OF PRITHVI

The first flight of Prithvi was done on 25 February 1988. When the missile was cleared for launch with such a large percentage of indigenous items, many were sure of one outcome – failure. After all, rarely had a first launch succeeded. The launch was a complete success, meeting all mission objectives and taking the world by surprise which led Dr Kalam to exclaim 'Funny Guys! They have done it!' He says further in his autobiography –Wings of Fire, 'It was an epoch making event in the history of rocketry in the country. Prithvi was not merely a surface to surface missile …… it was in fact the basic module for all future missiles in the country'.

SYSTEM LIFE CYCLE SUPPORT

System life cycle support was organised as per the following sequence.



BRR : Basic Requirements Review (for System Life Cycle Support)

- Logistics / supportability – Computerize where possible
- Deployment – Ease of Deployment, User Acceptance
- Training – Organized by BDL, PRITHVI Project
- Ease of use – Should NOT be officer dependent, learning curve considered.
- Technology upgrades – User or Project to offer / accept /demand
- Risk, Complexity and Turnaround time
- Retirement – Re-use and recycle, eg: Red Fuming Nitric Acid
  - Disposal, Neutralize Environment, Cost – Estimate and provide in budget

- Logistics / Supportability
- Receiving and Holding — Ordnance
- System and Spares — Depot
- Part nos, Catalogs — - Ordnance Rep in Project, Defence Standardization cell
- Training — - College of Material Management (Ordnance), Jabalpur
- Deployment — - Field Artillery, Missile Regiment
- Tactics and Operational — - Artillery School Training
- Maintenance – EME, Maint Adv Gp
  - Training – MCEME, Secunderabad
  - Periodical Calibration of INS – Cell in Ord Depot Field Repairs – Missile Regiment Workshop
  - Base Repairs – Identify through BDL
  - All Vehicles (Tatras) – Fully Covered by existing EME cover
  - Defect Reports – EME workshop, MSQAA, BDL, Design Agency

PROGRAMME STRUCTURE (IGMDP)

This was a major decision of Govt. of India and was implemented fully. It enabled the success of PRITHVI.

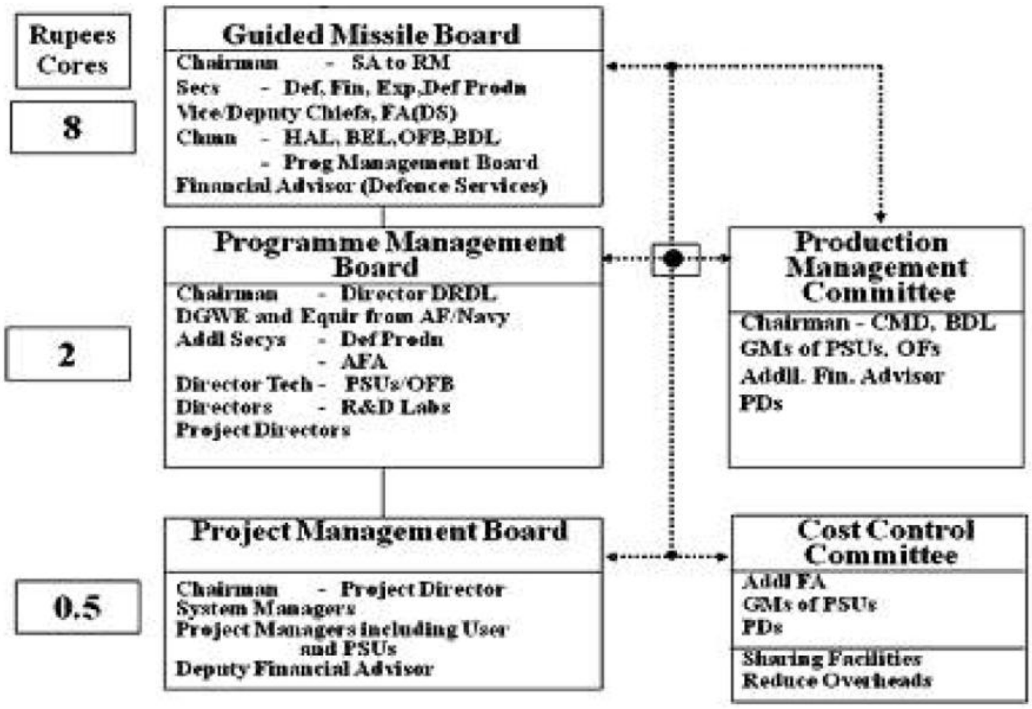


Figure 3 Programme structure (IGMDP)

INDUCTION INTO SERVICE

The Prithvi system was demonstrated to all Service Chiefs in November 1993. The user trials were successfully completed in June 1994 and the PRITHVI was cleared for induction into the Army in 1994 with 95 % indigenous items fulfilling the aim set for the Project. Subsequently Air Force projected a requirement for 250 km and later Navy (Dhanush) for 350 km. Both these versions were also inducted into service. This would not have been possiblein view of the subsequent sanctions imposed by the Missile Technology Control Regime (MTCR), but for the implementation of the initial decision to utilize maximum indigenous components.

The concept of Ballistic Missile Interception was validated in 2006 using a modified Prithvi to simulate an incoming enemy short range Ballistic Missile. A Prithvi incorporating a second stage propulsion motor was used as the interceptor (Figure 6).

SOFTWARE TOOLS

Software tools are now available for Project / Life Cycle Management and Execution and these should be used by all projects for more efficient execution.

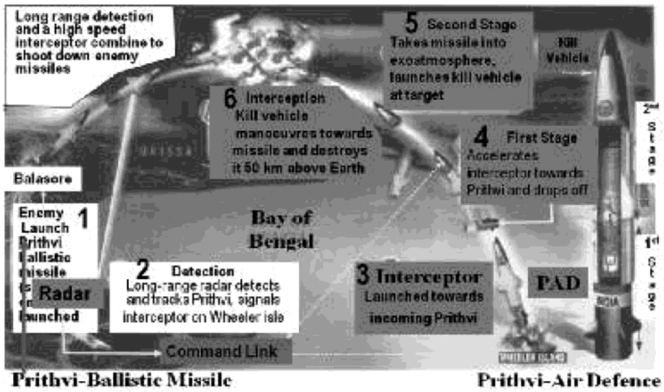
Army
150 km (1994)

Air Force
250 km (2002)

Figure 4 PRITHVI land versions

Navy
Moving to launch point-2007

Figure 5 Dhanush (350 km)



Prithvi-Ballistic Missile **Prithvi-Air Defence**

Figure 6 Ballistic missile interception – November 2006

DEVELOPMENTPROCESS AND BUSINESS ETHICS

IGMDP fostered a development process with strong sense of business ethics perhaps best summarized by the former Financial Advisor (Defence Services), Smt Neelkamal Narang. (Ref: page No. 254 IGMDP Book DESIDOC).

Features:

- Constant interaction with services so that user requirements were not lost sight of
- Realistic assessment of what we can take on
- Honest acknowledgement of what we cannot take on
- Collective decision making
- Built up Industry – Defence Partnership
- Parallel Manufacturer
- Ensured Transparency
- Quick Decisions
- Finance as an integral part of the team leads to better assessment and an in-built system of checks and balances
- Interaction of Project Director with higher levels of Finance for frank exchange and decisions.

Management Lessons:

- The management system evolved for the IGMDP, with five projects, enabled critical reviews of all parameters technical financial and user requirement. Project which utilized this system philosophy fully, delivered systems in reasonable time and cost, meeting user requirements.
- System will work if you have faith in the system.
- Recommend that this management system be adopted for major DRDO projects.
- Sense of commitment since you are part of a team.

CONCLUSION

For success in today's Globalized, Competitive World, the following are essential.

- AIM – Proper selection most important
- Resources – Realistic, Honest Assessment
- Major Projects – Mission Mode
- Partnership – User, R&D, Academia, Industry, Government
- Team Spirit
- Quality and Reliability
- SYSTEM ENGINEERING –Total Life Cycle
- Programme Structure
- Timely Decisions and Implementations
- Responsibility (Not Accountability) with Authority

ACKNOWLEDGEMENT

This paper evolved during discussions with engineers and scientists in courses organized by Engineering Staff College of India, Hyderabad, The Institution of Engineers (India) and National Institute of Advanced Studies, Bangalore.

Our thanks for how we were able to take decisions and implement them in Prithvi towards success go to

- The entire Prithvi family – wherever they were located in India.
- The users, work centres, laboratories, industries (both private and public), academic institutions, financial advisors, government and the political will.
- The management boards.
- Last but not least, the Funny Guys and their bosses who permitted such funny ideas.

India's Engineering Education in Search of Quality, Relevance and Excellence

Prof P B Sharma

Vice-Chancellor
Delhi Technological University

It is a matter of great privilege and honour for me to have been invited to deliver the 47th Nidhu Bhushan Memorial Lecture at the 27th Indian Engineering Congress, in the presence of the august gathering of the Engineering and Technology professionals from around the world who have gathered here to deliberate on the major theme "Engineering for Sustainable Development and Inclusive Growth – VISION 2025".

Shri Nidhu Bhushan Chatterjee was a great lover of science and its applications to the advancement of the human society. During his long illustrious career with the C.P.W.D. he served the society with utmost devotion and care and concern for nature. The father of the illustrious metallurgist Late Prof. Guru Prasad Chatterjee, he was a great believer of the dignity of man he lived a life full of humility and self-discipline. Today, when the human race has advanced to the levels of attaining near mastering over creation and acquire capabilities to scale the unscalable, the importance of selfdiscipline and service to self and to society and nature cannot be over emphasized. Our quest for sustainable development and inclusive growth mandates that alongside with science and technology capabilities we commit ourselves integrating human values with the capabilities. I feel truly honoured to have been invited to deliver this Memorial Lecture.

In India, today we are at the crossroads as far as our technical education is concerned. On one hand, we find that today's knowledge intensive industrial development is technology innovation driven on the other we find that we are reeling under the crisis of improving quality of our technical education system and achieving high employability of our graduates.

We need engineering and technology professionals for whom engineering is a passion and not just a profession for livelihood or career pursuits and it is this attribute in the engineering professionals which we need more today as the advancement of engineering and its applications are the major propulsive thrust for the growth and development of the human society. We need to ensure that India's education rises to meet the challenge of world quality in its curriculum and its delivery, for its preparation of the cadre of engineers who shall meet and greet the challenges at hand and shall be aspired to greet the challenges of tomorrow. We need also to ensure high level of industrial and societal relevance of our engineering education to assure higher levels of employability of our graduates and at the same time ensure that engineering education is aligned to the needs of the society. At the same time, we need also to ensure that engineering education creates those vital layers of engineering excellence which make engineering capable of creating the much needed esteem which the profession of engineering is expected to, in terms of development of new and innovative technologies, product design, zero waste manufacturing and delight in use of engineering products and services.

During the last 65 years of our independence, we have made great advances in engineering and technology education, succeeded in spreading our wings of knowledge and created the power of science and might of engineering in our country on the strength of our science and technology professionals and with our sustained focus on self reliance in major strategic sectors such as Defence, Atomic Energy, Aero-Space, Agricultural Engineering and also in Information and Communication Technologies. This has made India one of the strongest economies of the world and created prosperity for millions through the growth of new employment opportunities in the core as well as the service sector. Our manpower capabilities in science and technology sectors and our higher end skills of design and innovations have also attracted a large number of leading multi-nationals to set up their R&D and Design Centers in India. These include John F. Welch Technology Centre (JFWTC) of GE, Intel India Research Center, Imaging and Printing Group R&D Hub of Hewlett Packard, Microsoft Research India at Bangalore and Samsung's Research and Design Centre at Noida just to name a few. All this has created a highly conducive environment for the growth of Post Graduate Research in our country. Coupled with this are the major initiatives such as National Innovation Council established by Govt. of India, National Skill Development Mission and the National Knowledge Network which are the signs of India's commitment to revitalize its S&Teducation and research system.

But, we need to achieve a lot to transform India into a vibrant Global Knowledge Super Power which in turn shall position India into a country of great advantage in the community of nations in the New Knowledge Age. We need to, therefore, revisit our Science and Technology education system and carve out pathways for transforming our S&T education system into a system tuned to world quality, high industrial relevance and a system creating sustainable layers of excellence in science and engineering.

Let me, therefore, in this Memorial Lecture ponder for a while on the topic "India's Engineering Education in Search of Quality, Relevance and Excellence".

Quality and Employability- A Major Issue:

When we look at the current status of higher technical education in India we find that speedy expansion of Technical Education (Table1) has not kept its focus on quality and industrial relevance resulting into poor employability of engineering graduates, labelled as low as 25% by NASSCOM and other industry associations. Here again we find a glaring disparity between the leading technological institutions such as the IITs and other engineering colleges in the country. The prime differential is in respect of the very nature of activity pursued in these institutions. The IITs are institutions of higher learning established by the Act of Parliament as institutions of national eminence to engage in teaching, research and extension activities to empower the nation with world class human resources and science & technology capabilities. To a great extent this objective has been met by the IITs as their human resource output has been well recognized throughout the world for quality and employability. Further, the quantum of research output and support being provided by the IITs in respect of consultancies and other intellectual output are also well acknowledged, both at home and abroad.

Table 1 Impressive growth of Higher Technical Education in India

Type of Institution	1950	1990	2000	2011
Indian Institute of Technology	0	5	7	15
Indian Institute of Management	0	4	6	13
Indian Institute of Science Education and Research	0	0	0	5
School of Planning and Architecture	0	1	1	3
National Institute of Technoloy	0	13 (RECs)	17	30
National Institute of Technical Teacher's Training and Research	0	4	4	4
State Technological Universities	0	1	6	40
Colleges of Engineering and Technology	50	337	776	3288

Likewise, a few other premier institutions which include BITS Pilani, Delhi College of Engineering which is now Delhi Technological University, Jadavpur University, Thapar Institute of Engineering and Technology, Anna University (Main Campus), the Regional Engineering Colleges which are now NITs and the IIITs also over the years have emerged as globally recognized institutions for providing quality output. These institutions are also emerging as major centres of research and extension services and are being shaped as institutions of high national and global importance [1].

The poor quality of the outturn in great many engineering institutions is the result of uncontrolled expansion in respect of number of engineering institutions, non availability of quality faculty and poor knowledge infrastructure. This also is the result of the self-financing institutions focusing on maximizing intake rather than maximizing quality by their corporate governance and freedom to excel with bureaucratic hurdles being minimal in the development of the self-financing institutions. It was hoped that the self financing institutions shall take the best advantage of the freedom they enjoy to network with the best systems of academic and research governance around the world and shall accelerate the growth of quality in their institutions by adopting a three prong strategy of collaborative teaching and research, strong industry interface and global outlook. This could have provided them the necessary space to build quality islands and accelerate on the pathways of academic and research excellence despite the normal breaks and hurdles they may have to overcome being part of a large technical education system of this country. After all the world class universities such as MIT, Harvard, Stanford and Carnegie Mellon have all risen to the highest esteem having been established as private research universities. Nothing could prevent India's privately managed engineering and technology institutions to shape them as private teaching-cum-research universities and rise to the levels of world class universities in the next few years provided they create the desired vision, set their goals and targets and put in place a strategic framework to achieve their goals of world quality education and research with clarity and certainty. It is pertinent to note that despite such a low employability (around 25% as voiced by Industry Associations) India continues to be a prime attraction for manpower development and for outsourcing business and services for many advanced nations of the world. This is primarily because even 25% of the graduating engineers from India account for almost five times the total engineering graduates produced by American universities as a whole. See below the plot for outturn of engineering graduates, post graduates and Doctorates in US as per engtrends.com (Figure 1).

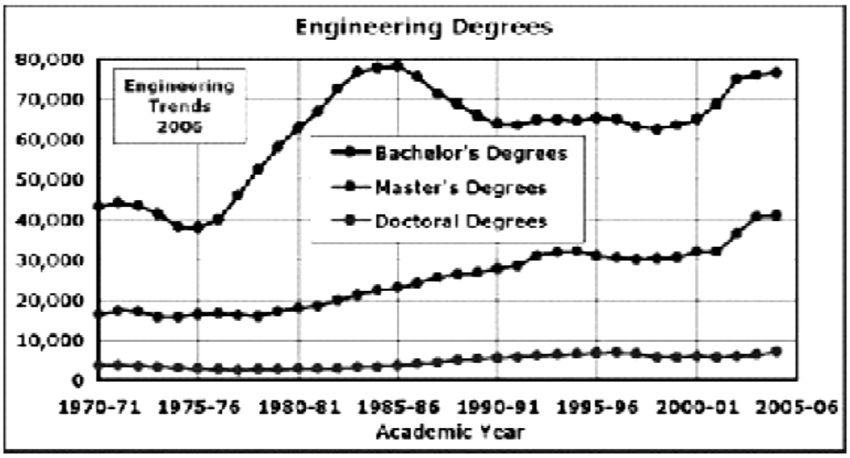


Figure 1: Ref: http://www.engtrends.com/IEE/1006C.php

But, India's technical education cannot remain complacent with this advantage of numbers as the large quantum of graduates remaining unemployable or under-employable shall ultimately erode India's technical education credibility. The time to act is now or else the poor quality syndrome of great many engineering institutions shall cripple India's technical education for good.

Global Accreditation – a dire need:

The Indian National Academy of Engineering in its 2010 publication on Profile of Engineering Education in India has recommended that "to achieve global excellence Indian Engineering Education must incorporate global competence as a key qualification of engineering graduates, give priority to transnational mobility of engineering students, researchers and professionals, develop strong links with professional practice and engage in engineering research in a global context." The Academy also recommends that India must line up its accreditation and quality assurance policies in tune with those now prevalent with the rest of developing countries so as to accelerate mobility of Indian engineers in all parts of the globe and help export Indian engineering services [2].

India's accreditation system for engineering education is under major reform as India is working towards obtaining a permanent membership in Washington Accord. This would require India's accreditation system a major revamp through its National Board of Accreditation (NBA). For a long time India's accreditation system for engineering education has been focusing on measurable parameters such as: infrastructure, faculty, examination results, research publications etc. It has not given due importance to the processes employed to achieve the desired outcomes. As against this, the Washington Accord mandates an outcome based approach for accreditation of engineering program. Here object orientation is given a much greater focus in terms of clearly identifying the approach to achieve the desired attributes in an engineering graduate.

As per Washington Accord 12 graduate attributes are stipulated to produce world quality graduates from engineering institutions. These include: the domain knowledge of engineering discipline, problem analysis and design / development of solutions, capability to investigate a given situation, use of modern tools of analysis and decision making, an engineer's capability to understand the aspirations of the society and assess the impact of engineering on societal development, knowledge of issues relating to environment and sustainability, ethics, capabilities to work as outstanding engineer and also in team often involving inter-disciplinary professionals, ability to communicate and manage projects and finances and capability to exhibit lifelong learning[3].

India's technical education system's search for world quality must, therefore, necessarily orient towards designing world quality curriculum and delivery systems to serve the development of engineering professionals having the vital attributes as stated above besides inspiring them to make the Profession of Engineering - a Profession of "Privilege to Serve" and "Privilege to Excel". This requires regular update of knowledge and skills of the engineering professionals during their work life to maintain the quality and standards of engineering competency and their strict adherence to the defined code of conduct for engineering professionals to maintain high competence to assure high dignity and honour for the engineering profession as shown in the Washington Accord diagram for the Engineering Professional Life Cycle (Figure 2).

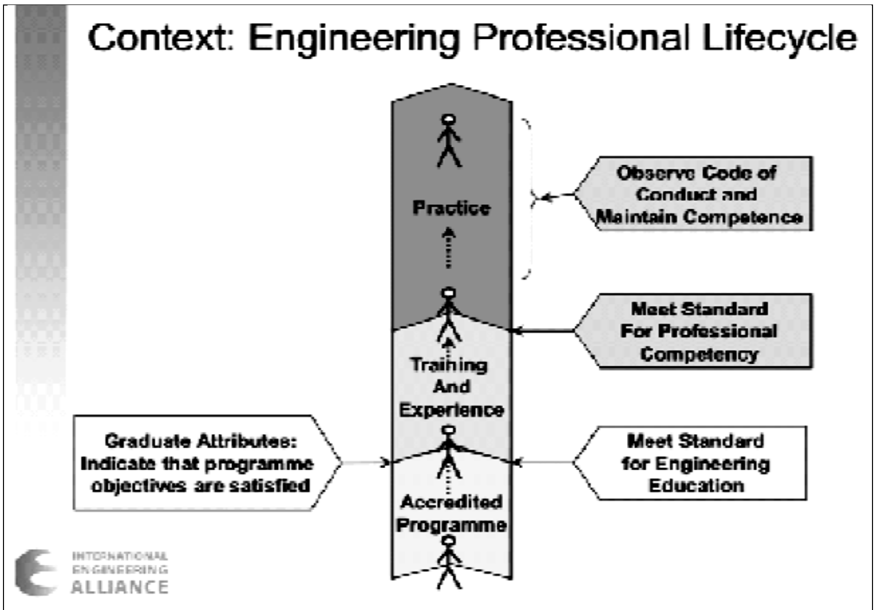


Figure 2:Ref:http://www.washingtonaccord.org/Washington-Accord/ Washington-Accord-Overview

The Quality of Faculty:

The second major issue relates to the quality of the faculty in engineering and technology institutions. Here again it is a matter of great regret that despite major revision of the pay package, the teaching profession in India remains as the least attractive proposition for the meritorious graduate of our country. The great rush in campus placements is for highly lucrative jobs in the industry and in the corporate hardly any top ranker looks towards teaching as a rewarding career. Compared to this we find that there is a great rush for research and teaching positions in universities abroad. Building a reservoir of quality faculty for India's vast technical education is a major challenge for the policy makers of our country.

Faculty not just as teachers but performing a triple role of a facilitator of learning (teacher in the new role), seriously engaging into industry relevant R&D, constantly engaged in advancing the frontiers of knowledge through cutting edge research and at the same time making all out efforts to transform the knowledge and knowhow into new product development and innovations is what is expected from the learned faculty in engineering institutions. Such an expectation becomes far more a distant dream when we have an acute shortage of quality teachers in our institutions of engineering and technology. The question remains what can be done to tackle this monumental problem in the shortest possible time.

Firstly, it is important to realize that the penetration of ICT and the impact of internet in facilitating the creation of a vibrant teaching learning environment are of great advantage which needs to be leveraged in engineering and technology institutions. Each institution could build in a short period of time a learning environment facilitated by ICT enabled network technologies and create a collaborative learning environment in which a high quality teacher is made available for a large number of students and to multiple classrooms, collaborative teaching involving teachers, students and experts from the industry could find a better meaning in such an environment. This will reduce the immediate demand for large number of teachers which is currently met by hiring untrained and often less competent teaching faculty. Secondly, we may also look at some innovative models for creating a teaching learning environment based on a cluster approach where a lead institution mentors a good number of institutions in the neighborhood such like clusters could be developed around IITs, IIITs, NITs and other leading institutions of engineering and technology.

A National Mission on Faculty Development is very much required to address this issue specially that integration of technology can do a much greater collective good to effectively enhance the teaching-learning process. We need technology-savvy, self-learning oriented faculty which is “inspired for teaching and driven by research and innovations” in our institutions of engineering and technology. The national mission could address this issue in a comprehensive manner as without quality faculty we shall fail in our responsibility to create the desired quality of out-turn from our institutions, nor we shall be able to accelerate our march on creation of new knowledge and new technologies.

Quality of Knowledge Infrastructure:

The third important dimension of quality relates to the quality of infrastructure which includes both the knowledge infrastructure and the governance of the institution. In this respect the self financed institutions having no bureaucratic hurdles can perform much better than even the institutions supported by the government and public funding. But then it requires a considerable investment on knowledge infrastructure such as connectivity, network, knowledge resources, portals and ICT enabled classrooms and creative research oriented laboratories. Institutions simply rely on the fee from the students often find it difficult to invest heavily in these areas while such an investment has become an essential part of our preparation to respond to the challenges of the new knowledge age.

Industry Interface – assuring high relevance of HRD and research:

The fourth dimension of quality relates to institution's interface with the industry. Here again we find that enabling mechanism for effective partnership between academia and industry is still lacking in very many institutions and universities in the country. The industry on one hand must realize that its requirement of qualified and trained manpower can only be met by the institutions if industry becomes a partner in progress with the institution. On the positive side we find that the IT industry has recognized this need and has responded favourably. The core and service industry must also recognize this need and come forward with Academia – Industry interface programs based on learning from the IT industry experience. The high employability of engineering graduates, their quest for creation of new and yet relevant knowledge and technology development in line with the current and future needs of the industry shall singularly depend upon creating strong industry-academia interface.

Technology Incubation and New Product Development to be made an Integral Part of Institutional Design:

For a very long time the industry in India has been dependent on the import of technology and design of products from abroad for its manufacturing industry. This has to a great extent dampened the spirit of technology incubation and new product development in engineering and technology institutions in India. This scenario is however undergoing a rapid change as the industry in India is rising to the challenge of technology innovations and new product development. With a view to respond to this growing need of the industry, engineering and technology institutions in India have to incorporate technology incubation and innovative product development as integral parts of the institutional design. In this new outfit the institution shall have its focus on quality human resource development alongside with the industrially relevant technology and new product development as its outturn. The existence of the technology incubation units and new product development facilities in the institutions shall give rise to a gradual transformation of Indian engineering institutions as global knowledge enterprises.

The rich pool of talent and innovative genius of students and faculty shall then find better expressions of their creative and innovative potential which in turn shall attract quality faculty and quality students to the institutions. The burden on high fees shall be largely offset by revenues generated from IPR and Technology Transfers. Student themselves would then recognize a much greater value and worth of the education and training they receive and shall be shaped as techno-entrepreneurs while still in studies in the institutions. This will give a major flip to student and faculty led startups which in turn shall fuel the accelerated growth of technoentrepreneurship in the country.

Let me therefore propose five vital connects for quality, relevance and excellence in higher technical education to revitalize India's higher technical education system. The five vital connects are:

a. Connect to Knowledge Network – The first and most important connect is the institutions connect to the vast body of knowledge. This will ensure that the power of connectivity and power of networking are well utilised by the students and faculty in comprehending the state-of-art as also to develop capabilities to work in today's knowledge intensive tech-savvy environment.

b. Connect to the Industries – This is absolutely necessary to focus on relevance. Industry partnership in delivering expert lectures, conducting technology workshops, participation in joint guidance of major projects and for internship to the students form the basics of the connect to the industries. This connect to the industries should further result into institutions and industries working together on new challenges of product innovation and technology development. In today's tech-savvy environment it is possible to take on board the local industry as well as industries in India and even abroad to strengthen this vital industry connect.

c. Connect to the Society – It is important that the institutions begin to focus on the society in which they are established so as to be partner in progress to addressing the major problems such as energy efficiency, energy conservation, environmental degradation, water quality management, creating trained manpower in areas of emerging and new technologies and as also partnering with local schools to create the desired interest in science and engineering.

d. Connect to National and Global Professional Societies – This connect ensures the vital flow of information and knowledge on latest happenings. Further, the professional societies provide the necessary expertise and support to comprehend new and emerging areas of technology and enhance institutions out reach to the vast body of research and knowledge resources being cultivated by researchers and practicing technologists the world over. Institution on its part can set up portals for curriculum watch, knowledge watch, technology watch, new product and innovations watch which can be developed in partnership with the professional societies. The advantage here is that the professional societies are well connected with the industries and as such can strengthen the industry connect of their institution as well.

e. Connect to Peer Groups – This vital connect promotes collaboration, cooperation and alliances with R&D organisations and universities at national as well as global levels. The institution on its part can take advantage of the peer group in these institutions / universities for strengthening its internal peer review so as to constantly assess and focus on quality and excellence. In today's knowledge age it is important to learn to collaborate and cooperate to maximise the impact of efforts invested in an activity. Engineering and technology education and research cannot flourish without effective linkages and mechanisms for collaboration and cooperation between universities and institutions in India and at the global levels. After all the IITs in India for the last many years have benefitted themselves from the collaborations with universities and R&D organisations abroad. In fact, they were set up in collaboration with a major foreign country and have since then maximised their quality and excellence with the collaborative structures which they have established with universities and institutions abroad.

Let me finish by adding that it is the right time for India's higher technical education to strengthen the above five vital connects to leap frog its quality, relevance and excellence. The opportunity to do so is already knocking at our door steps. I am sure this Indian Engineering Congress shall set out directions for revitalizing India's technical education.

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The Higher Education System & its Challenges

Prof (Dr) Kalyan Kumar

Vice Chancellor
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I consider it a great privilege to have been invited to deliver the 48thNidhu Bhushan Memorial Lecture during the 28th Indian Engineering Congress being held in Chennai. I am indeed grateful and thankful to the President, The Institution of Engineers (India) and his Council for the same.

As the Congress has identified the theme as "Engineering Advancements and Accelerated Nation Building", I wish to put forward my views and concerns on the topic of "The Higher Education System and Its Challenges". It shall also provide me with an opportunity to pay most respectful tribute to Late Nidhu Bhushan Chatterjee in whose memory this Memorial Lecture is to be delivered. Late Nidhu Bhushan Chatterjee is always remembered as an ardent lover of science and its applications to the mankind. Although he wanted to be an engineer, for he believed that one with love for scientific studies should alone become an engineer for better opportunities to prepare himself for better service to his fellow beings and the society, but by mere luck, he became a science graduate. Nevertheless, as a science graduate, he had a very long and bright career with an engineering department, namely the Central Public Works Department (CPWD), where he served the society with utmost devotion and satisfaction. He was a firm believer in the fact that only fundamental discipline in one's life can help him to set around from within to face life's challenges without fear or frustration. Now, it is with this background, in the light of Late Nidhu Bhushan's philosophy of what science can do to the society, I shall continue with the topic to lay my emphasis in this Memorial Lecture on the role the Higher Education has to play as a tool towards bringing in self-discipline and perfection in one's life; and such people ultimately decide the nation to grow stronger.

Introduction

India's success story of its rapid economic growth and emergence as the global knowledge power in a very short span of last two decades has definitely made us proud, but placed tremendous thrust on strengthening further the present higher education system. Also, India's continuously increasing role towards promotion of the global economy with the increased trade, investment, mobility of the trained manpower and various other resources across the borders has been of utmost concern to properly shape the higher education system to meet the new and emerging challenges in the 21st century. Although the country's higher education system has experienced phenomenal growth[1] since independence in 1947 until 2011-12 : 29 times growth in case of the number of universities from 20 to 574 and 71 times in case of the colleges from 500 to 35,539 along with the consistently rising trend of the enrollment of students in the universities and colleges every year (example: from 169.75 lakh in 2010-11 to 203.27 lakh in 2011-12 with the remarkable growth of 19.74 % in a year), the policy planners have to often deal with certain emerging problems such as the gradually rising trend of the graduate unemployability together with the lack of quality teaching, innovation, research and excellence[2], etc in our higher education system. In case of AICTE approved technical institutions[1?3], the number of such institutes saw increase from 11,809 in 2010-11 to 13,507 in 2011-12 (with growth of 14.37 %) against the increase in intake to 30.14 lakh in 2011-12 from 26.15 lakh in 2010-11 (with growth of 15.25 %). For more details, please refer to Table 1.

Whereas the present trend in development saw more and more institutions being established in recent years along with the students' enrollment also sufficiently enhanced, the relatively poor rate of "graduate employability" (say nearly 20 %) is posing a direct threat to the credibility of our higher education system. Truly speaking, the India's higher education system is facing the worst kind of challenges today owing to the shortage of qualified and experienced faculty and other support staff, lack of adequate infrastructure, significant gaps in the design of curricula meeting industry job orientation, inadequate linkage with the industry, poor quality of teaching, innovation and research, deficiency of industry exposure and internship during the course of graduation, etc. Moreover, the downward trend of our graduate employability in the context of ever increasing demand for the specialized skilled workforce all over the world becomes more relevant to identify and introduce the need based and location specific new courses and curriculum satisfying the industry's choice. Therefore, the UGC's 12th Five Year Plan (2012-17) document[3] attempts to draw attention of all the stake holders whether the governments, universities, institutions and colleges, industries, and employers, etc towards such pertinent issues of the India's higher education system which need to be reassessed and strengthened to ensure that the higher education system is result-oriented with a lot of visibility in terms of creation of the knowledge networks, skills up-gradation centres, R&D centres, innovation centres, centres of excellence, industry institute interface, faculty development institute, etc; and hence, has a definite goal to deliver "quality education" with "diversity" and "excellence". However, the quality education calls for thorough reforms in the higher education system by:

- Restructuring the higher education system to meet the global demands.
- Teachers setting up the trends to showcase the best teaching-learning practices.
- Ensuring quality, transparency, visibility and graduate employability.

Table 1 : Ministry of HRD, GoI annual report 2012-13[1]

No. of Institutions / Enrollments	2011-12	2012-13
Universities	523	574
Colleges	33,023	35,539
AICTE approved Technical Institutions	11,809	13,507
Distance Teaching Universities / Institutions	200*	200*
Enrollment in the Universities & Colleges (in lakh)	169.75	203.27
Enrollment in Open Distance Learning (ODL) (in lakh)	37.45**	38.56**
Enrollment in Post School Diploma/PG Diploma (in lakh)	18.56**	23.02**
Intake in AICTE approved Technical Programmes (in lakh)	26.15	30.14

[Source: UGC Annual Report, 2011-12 / AICTE Annual Report, 2011-12 / Statistics of Higher & Technical Education 2009-10 (Provisional) / * Repeated at the level of 2009-10 as per Prof. N.R. Madhave Menon Report of Committee to suggest measures to regulate the standards of education being imparted through Distance Mode // ** Estimated]

Restructuring the Higher Education System

The government policies and guidelines suggesting universities / colleges to identify academic programmes and courses need to be emphasized for enhanced quality and excellence in the field of higher education. This may require restructuring the higher education system by envisaging certain structural changes to be introduced while operating the higher education system with desired level of autonomy to the universities / colleges for strengthening of industry-institute interface, research and innovation, employability, and good governance, etc. Figure 1 suggests that the teaching-learning framework shall primarily focus on three major components namely, "knowledge", "skills" and "applications". The knowledge related inputs have to be decided keeping in view the global / international standards on one hand and the demand from the industry (or the stake holder) side on the other hand. However, merely taking into account of the programme / course structure and contents may not serve any purpose unless there is a firm national commitment to also ensure "delivery with transparency and accuracy" without any dilution of the quality standards or compromise with the accreditation process. The knowledge contents may be well enriched by the teachers based on industry-institute interaction allowing feedback to be collected from the stake holders whether industry, R & D organization, NGO or government agency. The main advantages of participation of the stake holders in deciding programme / course contents as well as development of new and upgraded curricula shall be judged by (a) addressing the various requirements of the industry with their role spelled out, (b) evolving appropriate teaching methodology and pedagogy as per university guidelines, and (c) planning for effective delivery mechanism to assure employability. With the industry-institute partnership effectively established, the faculty shall be able to overcome the deficiencies owing to the gaps between the course contents and the industrial practices; and this will lead to value added quality teaching. Similar to the knowledge, the other two components "skills" and "applications" have to also account for satisfying the broader goals of the higher education system in the restructuring of the academic programmes / courses towards sustained excellence. And, India with its assurance of teaching quality and excellence, and also, with the larger pool of the trained manpower at various levels whether executives, managers, supervisory and skilled or semi-skilled workforce should hopefully emerge as a favourite nation in facing successfully the global / international challenges in the 21st century to meet the ever increasing demand for the supply of the trained and skilled manpower.

Teachers to Set-up Trends Showcasing Teaching-Learning Practices It has been generally observed that the world's top university rankings normally give priority to the superior quality of research citation, teaching-learning practices, recognition of teachers and students, better student-to-faculty ratio, international diversity of students and faculty, graduate employability, industry-institute interface, etc apart from the excellent management of the infrastructure and ambience what the universities have to offer. That is, the universities have to compete amongst each other in terms of their products and services to demonstrate innovation, and also, implement academic programmes / courses with the best teaching-learning practices to showcase impact on the overall growth of the society. Besides, the sustainability of education and training is achieved based on the academic excellence for long many years with the proven track record of university's firm commitments to contribute to global learning with uniformity and transparency. It is also imperative that the percentage graduate employability is maintained at a relatively higher level. Thus, the teachers owe a lot of responsibilities with the support from the university management / administration in not only focusing on the best teaching-learning practices but ensure leadership quality in correct assessment of the challenges facing country's effective economic and social development planning and producing graduates for their successful career in their endeavour to fight against the poverty, irregularities, injustice and corruption; and also, to improve upon the social status of the under-privileged, below poverty line and grass-root level youth towards self-reliance and country's prosperity. Figure 2 illustrates the basic structure and qualitative features of the top ranking world class university.

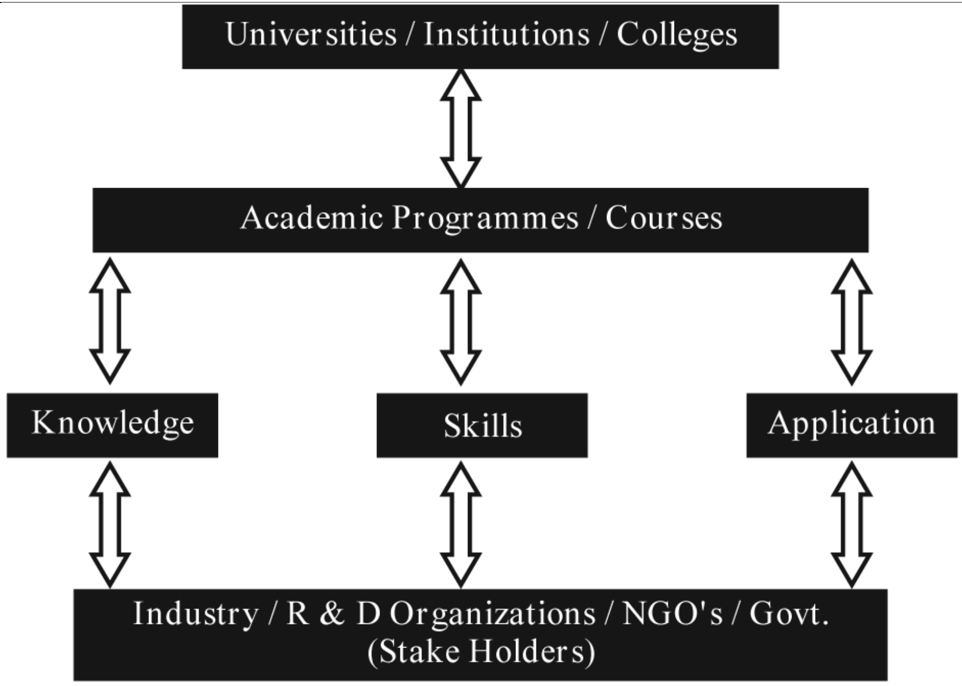

Figure 1 : Higher education academic programme structure

Notwithstanding that the continuously increasing application of the “technology enabled learning tools” has given immense benefit in accessing educational and reference resources for collecting vast supplementary materials for improved teaching-learning practices, research and innovation, Susan Henderson4 said “Technology allows students to become much more engaged in constructing their own knowledge; and cognitive studies show that ability is key to learning success”. Truly speaking, technology is changing the concept of today's classrooms by introducing very flexible type self-learning management tools which can help students preparing course work beyond classrooms but “on-line” from anywhere, and that too, with the virtual classroom. Such methods are gaining importance to find increased applications in the near future in improving connectivity to the knowledge domain; and with the kind of in-built flexibility, these may help teachers and students undergo teaching or academic exercises. Knowledge transfer using technology enabled learning can also connect the communities in remote locations and far-flung rural areas for being educated to be brought to the main stream of the society and serve the society in variety of sectors such as education, environment monitoring and pollution control, health and hygiene, agriculture and food processing, forestry, drinking water quality monitoring and testing, sanitation and cleanliness, non conventional energy sources, etc. Since India's overall development is linked with its grass-root level education and training because 70 % of the population live in villages, the country's economic empowerment and prosperity would be ensured when the common mass are converted to educated workforce and provided with the gainful engagement / employment. The world wide attention on the development of "on-line" and "e-Learning" courses now finds relevance, and thus, turns out to be a favourable alternative to the conventional classroom teaching. The technology supported web-based learning, computer-based learning, virtual classroom concept of teaching, etc are becoming quite popular amongst the students and in-service employed candidates who have curiosity to enhance knowledge and skills.

Quality, Transparency, Visibility and Graduate Employability

The Quality Assurance (QA) is an essential ingredient. The universities, government and government aided colleges, and also, private colleges need to follow mechanisms ensuring quality teaching for quality assurance. There are laid down norms and guidelines for quality assurance and accreditation process. However, the university has to comply with fulfilling the country's needs as well as international expectations and standards. Quality improvement measures are consistently being tried in the higher education sector so that the general public has the awareness about the recognition of the educational programmes and institutions that fulfill the desired quality standards as stipulated by the respective statutory bodies. The private institutions have to take larger share in the spread of global education in the 21st century.

While the quality and excellence in higher education is strongly tied up with good governance; it is expected that the university / college management takes initiative to introduce an effective governance system with transparency and objectivity, based on adequate participation and inclusion of all relevant stakeholders including students, governments, faculty and staff, employers, etc. The good governance has to go a long way beyond just establishing organizational structures, policies and procedures; and should result in direct visibility and impact on necessary transformation in the way students benefit from the academic programmes to select their successful career whether teaching, R&D or industry to help society grow. Even promotional strategies for knowledge sharing and building regional and international collaborations with discussion on mutual benefits or meeting global challenges establish the reputation of the university / college to be of world class. It is also observed that many universities in recent time prefer to have tie-up with the employers to develop a more useful curriculum dealing with the requirements of the employers, with a view to orient students with increased employability skills to suit to the industry.

Employability is defined by Vicki Tariq[5] as "A set of skills, knowledge and personal attributes that makes an individual more likely to secure and be successful in their chosen occupation(s) to the benefit of themselves, the workforce, the community and the economy." Since the employers have a lot of expectations from the fresh graduates, it is often experienced that universities emphasizing on grooming the graduates with "basic skills" and "desired professional competency" have definite advantage in ensuring increased graduate employability. This has also put emphasis on using "technology" to enhance learning, both computer technology and video, as well on initiatives to enhance students' employability skills and workplace experience.

The World Class University

In recent years, the term "world class university" has become a buzzword to be used very frequently. However, it still remains to be answered as to

- What does it really mean ?
- Whether it refers to university which is considered the best (par excellence) ?

In my opinion, the world class university should successfully achieve its three purposes such as (i) teaching and learning; (ii) research and innovation; and (iii) community services. Also, the university builds its own reputation to get established with an elite status which is conferred by an external organization. It may be implied that the university / institution must fulfill a predefined set of criteria and standards of excellence which are internationally comparable. Although the university which enjoys a relatively higher ranking at a national level may have a chance to perform extra in order to develop and establish itself within international rankings.

In spite of the flexible approaches playing significant role in the university ranking assessment world over based on a number of diverse technical parameters, there has been continuously increasing public attention over the past two decades about the prevailing competition to be ranked among the world's top universities. Generally speaking, the reference of a benchmark for universities is made based on the well established leading higher education university / institution in the world; and thus, a direct comparison with this university / institution on quality of education, excellence, graduate employability, etc may decide global ranking for any other university / institution under the competition.

Whatever ranking system one may opt for, it is believed that a relatively higher ranking university is that making significant contribution to the advancement of knowledge through teaching-learning practices, research and innovation, advanced curricula and pedagogical methodologies, and produce graduates who are quite competitive and easily employable. Such leading university / institution of repute together with the track record of its significant contribution to the sustained growth and development of society may be termed as "world-class". Figure 2 presents a simple model structure of the qualitative features of a " world class university ".

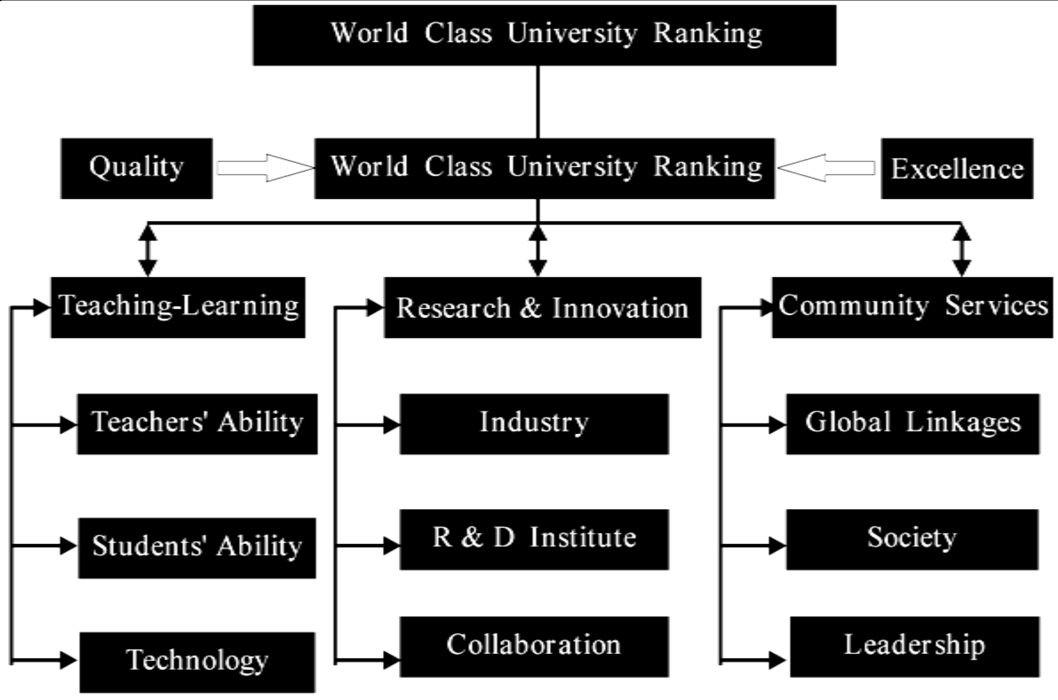

Figure 2 : A world class university & its ranking

The Corporate Social Responsibility & It's Impact on Higher Education

India's corporate sector has experienced business and industrial houses coming together to promote social growth and social good. They have drawn resources from the society and added values to generate wealth. Also, society and business are inter-dependent; and business is capable of meeting social challenges to fulfill societal expectations. Whereas a stable social environment is a pre-requisite for business investment and industrial operations, the industry needs to facilitate such environment by taking care of the concerns of the society. A company usually aspires for the well being of its employees and their family members; however they need to look around the people with full responsibility as a corporate entity addressing to the socio economic and environmental concerns of the community to (a) conserve environment; (b) maintain the quality of ambient air and water within the prescribed norms; (c) best utilize skills of employees in company's affairs; (d) skills up-gradation of employees by imparting technical and managerial training; (e) provide educational facilities to the children of employees, etc. In general, these concerns of the community reflect the aspirations of stakeholders and of citizens eager to actively participate in economic growth and development, and can be classified under three major categories:

i. Comprehensive Plan for Sustained Growth of Community and India's Economy: self employment generation, entrepreneurship, education & training, etc.

ii. Welfare and Community Services: help to poor and needy children of BPL families, meritorious students, free medical camps and ambulance, etc.

iii. Rehabilitation and Resettlement of the Affected Families (land donors): organizing short duration training programmes for women on tailoring, embroidery designs, home foods/fast foods, pickles, painting and interior decoration and other vocational courses, and formation of SHG for generating self employment.

While it is expected that more and more companies would make sincere efforts to consider compliance of CSR in promotion of education, promotion of gender equality and empowering women, and employment oriented vocational skills, the business strategy can have focus on creation of better opportunities to ensure the "quality" and "excellence" in higher education universities / colleges. The companies should gradually try to align their CSR policies in association with universities / colleges of higher education towards strengthening of existing processes concerning R&D activities, innovation, discoveries and inventions, development / advancement of technology, new product design and development, etc. It is indeed desired that governments and their machinery come forward to establish synchronization between companies and higher education universities / colleges to ensure greater and visible impact through collective efforts in pushing the India's higher education system to be one of the best in the world. However, the joint teams to be set up under the CSR initiatives of companies and universities / colleges should aim at establishing as follows without any further delay:

i. Centres of Excellence (CoE) to offer quality and excellence to higher education.

ii. Centres of Advanced Studies (CAS) to identify advanced academic programmes and inter-disciplinary fields of studies contributing innovation and inventions.

iii. Faculty Development Institute (FDI) to ensure that faculty shortage is overcome; and the young and middle level faculty be trained in their subject field(s) to emerge as domain-wise leaders in near future.

Conclusion

Irrespective of the considerable gap(s) as prevalent between the existing curriculum and the industrial practices, the country's higher education system demands for enhancing the standards of academic, professional and inter-personal development activities. Besides, the learners need to be trained in terms of the emerging technological and developmental changes sought by the industry and employers. Thus, the role of the higher education institutions / universities has become more significant in finding new challenges of introducing appropriate teaching-learning practices, research, innovation and invention, and community services to facilitate graduate(s) with enhanced level of subject knowledge, skills and applications to ensure better employability. With the learners' ability multiplied manifold under the corporate-academic partnership and the country's higher education system increasingly emphasizing on India's growth prospects and socio-economic challenges, there is higher possibility of universities / colleges to equip and motivate graduates in playing a key role in today's world of knowledge economy. However, the teachers have to plan for all such necessary changes, and take the lead in their institutions to face new and emerging challenges in the 21st century while overcoming deficiencies coming on the way of graduation with employability.

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Technological Innovations and Economic Growth — India's Emerging Role

Mr M Gopalakrishna, IAS (Retd)

Former Special Chief Secretary
Government of Andhra Pradesh

I am thankful to the President of The Institution of Engineers (India) and the Chairman of the Andhra Pradesh State Centre of the Institution for inviting me to the 29th Indian Engineering Congress at Hyderabad and deliver the 49th Nidhu Bhushan Memorial Lecture, so lovingly instituted by his son Late Professor Guru Prasad Chatterji.

In tune with the theme of the Congress, "Technological Innovations and Economic Growth - India's Emerging Role" and the philosophy, vision, hope and aspirations of Late Nidhu Bhushan Chatterji, I will talk on "Technological Innovations and Role of Engineers for Economic Growth" to pay tribute to Shri Nidhu Bhushan Chatterji a student of science who yearned to be an Engineer and could not become. He yet served the cause of engineering sincerely by joining the Central Public Works Department as an Accountant. By dint of hard work, he rose to the rank of Inspecting Accountant in the Finance Division of CPWD. His commitment to science and its applications in a Government Department is praise-worthy. His vision and passion for service to the nation through determination, discipline and dedication to the cause of technology and innovation is an example worthy of emulation by engineers.

Advancement of science, technology, engineering, entrepreneurship and innovations are necessary for economic growth. The connectivity and linkages between them is equally important. My talk will give an overview of the framework of policy and the role of engineers to propel India towards economic growth and emerge as a global economic power.

Introduction

Science is the systematic study and codification of knowledge acquired from observation, experiment and experience. Basic research leads to discovery, understanding and development of Science. While basic research probes and enunciates the principles of science, applied research converts the basic research to useful applications. Acquisition of scholarship and knowledge drives basic research. Applied research is need-based, demand-driven and comrnerciaIly oriented. Technology is the systematic application of science with relevant skiIls, tools and techniques to provide solutions. While applications of science become technology, application of technologies become engineering.

Science, Technology, Engineering & Mathematics (STEM) Education is expected to enlighten, enable, empower, generate ideas, develop entrepreneurship, create employment and wealth and pave the way to economic growth. The prime mover of economic growth is education with emphasis on application of Science, Technology, Engineering and Mathematics (STEM). Such a system of education can ensure steady and sustainable growth. India must adopt a STEM type of practice-oriented education and skiII development as has been done in the developed countries. Humanities, Ethics and Values that help character formation, build credibility and social responsibility is equaIly essential.

Need for improvement of Educational Standards

There is a proliferation of educational institutions and professional coIleges in India. We have today 574 universities and 35, 600 coIleges. There are 3, 345 engineering coIleges with 1.4 miIlion seats but the standards of education and knowledge of students are very poor. Only 15% of the engineers who pass out are employable! The silver lining is that institutions like the IITs, IIMs and some Business Schools are doing well but their numbers are limited. However, even they, do not figure in global rankings indicating the long leeway to be covered. Improving standards of need-based, nation-building education, teaching, learning, researching and providing experiential understanding leave much to be desired. Focus on curricula development, soft-skills, work-orientation, faculty training and development, student-faculty ratio, research, publications and doctoral studies cannot be over-emphasized. Excellent educational Institutions can empower students to spawn Innovation, Innovators and Entrepreneurs.

Academia, Institutional, Industry and Government interface and interaction has to be close and continuous to maintain and improve standards. Engineers could be part or full time instructors and teachers and link theory with practice and class floor with shop floor.Professors in turn, could work in industry. Such interaction would be mutually beneficial and upgrade and popularize technology usage.

Research and Development

Research and Development requires quality manpower with relevant and latest knowledge, skills, experience and expertise. Guides and mentors are important. Research and Development must go hand in hand with Human Resources Development. This involves attention to the process of inform - include - interest - influence - instruct - involve - inspire and aspire to excel. In short, R&D must go hand in hand wi th HR&D.

According to available data of researchers per million people, India has about 150 researchers against 5085 for Japan; 4526 for USA; 3415 for Russia; 2691 for UK; 900 for China and 500 for Brazil. India has to produce more researchers to gain a reasonable share of global patents.

Applied Research and Development enables to find solutions, increase competitiveness, add value, enhance productivity and reduce cost. To do so, the linkages between academia, scientific establishments, industry, corporate sector and civil society – the ultimate stakeholders - has to be strengthened. This can propel the country to become an economic power and in time, a super-power. With a large population, poor Human Development Indices but advantageous demography, we need to emphasize Education, Health, Enterprise and Innovation for faster economic growth. In India's context, accelerated Research and Development should become Result and Delivery.

Science &Technology Policy Resolutions

India introduced the Scientific Policy Resolution (SPR) as early as 1956 to create awareness of the importance of science and the cultivation of 'scientific temper' in the country. This was followed after a long gap of 27 years with the Technology Policy Statement (TPS) of 1983 in which the need for building technological selfreliance was stressed. In 2003, the Science and Technology Policy (STP) was announced calling for larger investment in science and technology. India announced 2010-2020 as the decade of innovation to be achieved through synergisation and connectivity of science, technology and innovation.

The National Innovation Council was also set up. The intention is to integrate science, technology, innovation, engineering and entrepreneurship for value creation, competitiveness, cost reduction and productivity. Such a linkage can lead to faster and inclusive growth. India will have to simultaneously develop global level of competence in selecting emerging frontier sciences like genetics, biotech, space research, ocean technology, missiles, nanotechnology which are of relevance to India.

Technology - Necessary for Economic Development

Technology is the means by which national and business objectives are achieved. It is the driver of socio-economic development, inclusive growth and improvement of the Human Development Index. Science and technology get a fillip with knowledge, physical and electronic connectivity. A supportive ecosystem can playa very vital role in taking the benefits of technology to rural areas. Science and technology can upgrade indigenous or conventional technology from labour-led to knowledge-led, low-tech to hi-tech; including green and clean technologies. Science and technology with sharp focus can cut the lead time for product development and reduce lifecycles besides supporting grass-root innovations. Technology must help meet national needs and increase technology exports in specific sectors of excellence to other developed and developing countries.

The relevance of indigenous technology arises because foreign companies are more interested in setting up their own factories in India to take advantage of our qualified manpower and large market rather than transfer of relevant technology. They have a lurking fear that Indian companies with enhanced research and technology capabi lities could develop both reach and lead over them and become globally competitive with low cost solutions. No wonder, they are buying out many of our ventures and joint ventures! Foreign firms with large investments on research and financial muscle will, gladly farm-out research jobs, but hold on and control patents over products, a word of caution. Cutting edge technology could be the leading edge or the bleeding edge! We have to carefully evaluate.

Innovation

Innovation is the implementation of a creative idea to make it a commercial success. The idea has to be defined and refined. This is succinctly referred to as the path from 'insight' to 'foresight'. This creative process is distinctive and has to be led, managed and measured. The process could be evolutionary, revolutionary, incremental, transformative, radical or disruptive. While technical feasibility, economic viability and financial soundness have to be established, the idea must be novel, add value or reduce cost, be competitive and become a commercial success. All innovations require a Business model and Revenue model and imaginative implementation to establish its commercial success. The demand for innovation usually comes from the market. If needed, the innovation creates the market by securing the mindshare and excitement of customers. An innovator does not think of one solution but many solutions! Hence, he provides choices to provide satisfaction to customers or remove dis-satisfaction.

All ideas and initiatives first arise in the mind and then happen on the ground. "Nothing is more powerful than an idea whose time has come". Winston Churchill said that "The empires of the' future will be the empires of the mind". Imagination generates ideas and drives initiatives while innovation makes it acceptable, scalable and commercially successful. Innovation is the hallmark of entrepreneurship which provides competitive advantage and meets the customer's needs. Such innovation has to be available, accessible, adequate, appropriate and above all, affordable.

Innovation is multifaceted and can manifest in the structure, in the process, in the product, in the service and in utility and versatility. It has to be reliable, operable, maintainable and effective in delivery. For India, innovation is the idea whose time has come. No wonder that we have the corporate adage, innovate or evaporate!

Change Management

Innovation helps to seamlessly bring about change by linking the past with the present and the future. It is moving from the known to the unknown. It has to face volatility, uncertainty, complexity and ambiguity. It is not the speed of change that should worry us but the slowness of our response to change! We have to anticipate, advocate and prepare for change. If necessary, we may have to precipitate change! Change has to be led and not managed. Hence one has to read the change, heed the change, lead the change, be ahead of change and ride the change.

Need for Clarity

The innovation process requires clarity of the concept, context, content, connectivity, continuity, communication, coordination and collaboration. It needs clarity of goal, role, responsibility, resources, route, results, recognition and rewards as well. Innovator has to adhere to the principles of "logos, pathos and ethos" i.e. sound logic, deep passion and ethical action for self actualization and goal fulfillment.

Innovation links knowledge, science, technology, understanding of market needs and best practices for wealth creation. Innovation is the hallmark of entrepreneurship. Entrepreneurs succeed, because they are prepared to take advantage of opportunity. Peter F Drucker, eminent Management expert, said that "Innovation is the specific instrument of entrepreneurship. The act that endows resources with a new capacity to create wealth".

Entrepreneurship

An entrepreneur is one who sees, perceives and seizes an opportunity or creates an opportunity. He enters a new area, takes a preview and knows the core requirement. It is said, "When preparation meets opportunity, success follows". Entrepreneurs are intrepid explorers and prefer to walk the untrodden paths. They explore opportunities to add value, become competitive and acquire customers by assessing felt needs. An entrepreneur requires vision, passion, mission, patience and perseverance. He evaluates the scale, scope, skill, speed, sources and resources, services and sustainability of the idea and the venture. His focus is on purpose, process, people, productivity and profitability and in securing the first mover advantage. Many corporates, institutions and organizations have chosen to be entrepreneurial like DuPont, 3M, Toyota, Starbucks Coffee and many Indian companies as well, particularly, in the I.T. Engineering, Automobile and Pharma Sector. Their emphasis is on training, team-building, state-of-art technology and its adoption, trends. Analysis, tight timelines and number of patents filed and obtained and the extent of commercial success.

Economic growth has world-wide been accelerated by support to entrepreneurship and innovation. In the US, the Silicon Valley ecosystem has been singularly successful in spawning many an enterprise and continuous innovations in futuristic technologies. It is heartening to note that Indian entrepreneurs in Silicon Valley constitute the second largest group of entrepreneurs after US citizens!

The potential with our large number of engineers and scientists who pass out every year, our Diaspora, NRIs and the High Net Indi viduals and the 48 million SMEs we have in India-the second largest number in the world (China has 50 million)-can well be imagined. We have to tap this endless resource and make the potential a reality.

India has several success stories to its credit in drug discovery and vaccines manufacture, automobiles including the Nano, spread of mobile telephony, space exploration and growing self-reliance in defense requirements and the spectacular achievements of ISRO.

Entrepreneurship for Employment Creation

Entrepreneurship can create employment opportunities. The corporate sector in India has not been able to generate the 12 million jobs that the country needs every year. India has to consciously support the Entrepreneur - Innovator, who is the real economic catalyst for national development. It is the qualified and skilled youth who constitute our demographic dividend that can fill the gap and provide the required impetus by providing private solutions to public problems. We have to enable and empower entrepreneurs while institutions and corporates must encourage 'Intrapreneurship' to build the national pool of Talent and 'Entrepreneurship' for fast delivery.

Upgrading the technology of the micro, small and medium sector of industry could work wonders. The large number of Engineering and Management Colleges could develop grass-root entrepreneurs and innovators and mitigate risks, trouble-shoot and prevent sickness in industry. They could help transform the SME sector as the real engines and prime movers of economic development.

The entrepreneurial eco-system should start with simplification of procedures, an efficient single-window system, sound incubation arrangements, availability of Angel and Venture Capital, financial and mentoring support and labour reforms. Government would have to facilitate access to funding, creation of Innovation Hubs, Knowledge Parks and an Accreditation framework as well as collaborative arrangements. Easy entry and exit systems for industry should be provided. We need the PAL of Partnerships, Alliances and Linkages and Public Private Partnership.

Start-up villages in rural areas and reformation of Special Economic Zones, Knowledge and Industrial Parks and Incubation Centres could usher in the Innovation Decade.

Role of Government

The framework of policy, laws, regulations, institutions and processes must be reviewed with emphasis on good governance. The PMs clarion call has been "Sabke Saath - Sabke Vikas" - All together - All develop together. To do so, Government has to create the climate and fervour required for economic growth. It could start with a gap analysis of required global level of knowledge, technology, talent, performance, innovation, entrepreneurship, strategy, competence and credibility and the present available level of the nation to bridge the gap between promise and performance. The existing asymmetries between our culture and requirements of science and technology must be bridged i.e. the gap between generation of knowledge and its absorption, gap between development and delivery, investor and innovator and availability and affordability. The education policy must emphasize practical applications of knowledge and skill development and create passion for research and development along with human resource development. Academia - industry - institutional cooperation; partnerships, alliances and linkages and public private partnerships should be encouraged.

Government will have to create the infrastructural, investments and innovation climate and culture for innovation and entrepreneurship to flourish. Government will have to re-engineer itself to meet the changing needs. A word of caution is relevant. Government must enable and empower, not micro manage matters. Socio-economicdevelopment requires millions of individual decisions supported by society and facilitated by Government. To make our policies, plans and actions effective, we need political will, managerial skill and societal goodwill. The Institution of Engineers (India) must mobilize public goodwill and facilitate the awakening of the nation to its immense potential.

Engineering

The word Engineer comes from the Latin "ingenium" meaning innate quality, mental power, or clever invention. Engineers are credited with some special skills like incisive thinking, imagination and insight, supported by initiatives, innovation and implementation. Engineering as a field of discipline, profession, practice and art, has always been related to the development, acquisition and application of science and technology, to new initiatives in the design, development of innovation, invention and judicious use of materials, machines, structural systems and processes for specific purposes. Engineering which is an interdisciplinary science and practice for social benefit will have to ensure sustainable economic growth by fostering innovation and improving productivity, conserving non-renewable resources and increasing use of renewable resources like solar, 'wind, hydro, geothermal and biomass in an appropriate manner. To do so, Engineers have to improve their individual proficiency, collective efficiency and national effectiveness along with respect and reverence for nature and society to the achieve national goal of a global role.

It is said that the "Scientist has to know; Engineer has to do." "Scientists study the world as it is; Engineers create the world that has never been". Engineers are thus visualizers and creators. Engineers transform sight to insight and insight to foresight! It is said that for everyone, "what is visible is possible". But, the "Engineer sees the invisible and does the impossible" Engineers turn vision into reality by their passion for action! Engineers have dreams (Kalpana) but it is their determination Sankalpana that makes their Kalpana (dream) come true! ! I can do" is their Mantra.

Engineers must become Leaders

Engineers must be listeners and learners. They must learn, unlearn, relearn and continuously update themselves. Engineers can strengthen their creative powers by harnessing the powers of "reading-thinking-questioning-knowing-doing- understanding - becoming and being leaders!" To become leaders, they have to develop their powers of attention - concentration, observation - memorization - imagination but not let it go riot but hold it firmly by discipline of thought, word and deed i.e. manasa-vacha-karmana. To do so, they must strengthen personal insight along with technology foresight in a broader, long term perspective to enable them to make correct choices and take correct actions despite the shifting landscapes, uncertainties, inadequate data and insufficient resources. Future possibilities must be balanced with awareness of barriers and dangers in availing of premature opportunities and late realization of objectives.

Engineers have to keep in mind, predictability, scalability, sustainability, risk-mitigability, productivity, longevity and profitability. They have to create and add value at each stage of the value-chain and work towards productivity enhancement, continuous growth and development. Knowledge must be tempered by wisdom which says that you must give more than you take from resources.

The barriers to innovation are low self-esteem, negative feed-back, status quo mindset, lack of guidance and mentors hip and inadequate moral and material support. The barriers must be broken down by determined action. We can do, We can succeed must be our creed.

India's Advantages

India's advantages are its democracy, demography, diaspora, diversity and demand. Engineers have to continuously think of technical innovations, national interests and global competitiveness. They must hone their skills to build better, faster.jcheaper, safer, secure, simple, scaleable and user-friendly products, processes and services for improved outcomes and impacts. With cutting edge technology, India could well become the global leader. Engineers have to therefore think global, act local, be focal and where necessary, be vocal!

Inclusive Growth

Engineers have to integrate innovation with ethics that ensures sustainability while providing for faster growth which is inclusive, equitable and sustainable. Inclusive growth must provide opportunities; build capacity and competence, provide access to opportunities and ensure security of food and nutrition, health, water, energy, environment, employment, housing and habitat and livelihood.

Need for Ethics and Values

Ethics is concerned with the ethos or spirit of service, the very breath - Swasa of life - and ethikos, its conversion as a habit of social responsibility. It is concerned with morals, a code of conduct, good behaviour and values like integrity, impartiality, neutrality and humanity. Engineers who are familiar with value engineering will now have to engineer universal values like truth, trust, transparency, tolerance and technology that is benign with tactfulness. Engineers have to become adept at both technical and social engineering and become social engineers. Excellence comes from the human and professional ethics followed by engineers in their work and day-today life. Professionalism is the refinement and forward movement of the human being and application of his knowledge from the "service of the selfto the selfless service of society".

Engineers must adhere to ethics and values and follow an universal code of conduct which accepts responsibility in making decisions consistent with the safety, health, and welfare of the public, and to disclose promptly, factors that might endanger the public or the environment. They have to consciously protect ecology and develop benign technology and increase productivity. Engineers have to assist colleagues and co-workers in their professional development and support them in following the code of ethics and resolutely reject bribery and corruption in all its forms.

Indian wisdom prescribes that engineers must utilize the four godgiven faculties and factors of performance. i.e., Gyana Shakti or the power of the intellect, Prana Shakti, or the power of the spirit, the life breath, Iccha Shakti or the power of desire, love, longing & belonging and Kriya Shakti the power of execution, result and delivery. These four faculties require the support of the Karta, the person who has to perform, Karayitha, the Person who has to monitor and mentor and get it done, Preranascha, the Motivator who has to inspire and Anumodaka who has to approve i.e. the society.

To succeed, there is only one Mantra, one Sutra. Success demands that every engineer should do his home work, put in hard work, ensure smart work, build team work and create a network. I am sure that this congress will help enlarge the network of engineers in India and world over and reinforce their will and desire to create a brave new world.

Asma Bhava, Parashu Bhava

All education and professional knowledge is to strengthen the determination and sharpen the intellect. The clarion call given to all graduates passing out from the ancient Takshashila University in India wasAsma Bhava, Parashu Bhava. Be as strong as a rock in your determination and as sharp as a battle axe in your intellect to fight poverty and win the war of prosperity. Engineers must be crusaders in the war against ignorance and poverty.

Break your Bounds

Maharishi Patanjali, the father of Yoga Suthra, stressed the importance of purpose, inspiration and aspiration when he said.

"When you are inspired by some great purpose, some extraordinary project,
all your thoughts break their bounds.
Your mind transcends limitation, your consciousness expands in every direction,
and you find yourselfin a new great, and wonderful world.
Dormant forces, faculties, and talents come alive
and, you discover yourself to be a greater person by far,
than you ever dreamt yourself to be.

In other words, "*why crawl when you canfly*".

I wish that the Engineers assembled here discover themselves to be far greater than what they dreamt they are and excel themselves, exceed the expectations of society and expand their outlook, personality and achievements. I pray that Engineers provide more benefits with less resources for more people.

Make in India - An Incredible India

Engineers have been nation-builders, technology-creators, solutions-providers, infrastructure-constructors, machine-builders and persons who make life easier, though, living may not be so easy! They should measure themselves against their output ofInnovations, patents and inventions and their outcomes and impacts on society which is the ultimate rating. They must make "Make in India" a reality and economic growth Incredible! That will truly make India- Incredible and Invincible. "Sabke Sath Sabke Vikas".

In this mission of "Make in India", the 49th Congress of The Institution of Engineers (India) has a duty to encourage "noble thoughts from all over the world" (Aano-bhadrah Kruthavo yanthu Viswatah) and spread the message that Indian engineers can take initiatives, innovate and usher in the resurgent India in an incredibly short time. In this task, let us see inward, look outward, move onward and together, go fast forward to build a prosperous India and contribute to world progress. Let that spirit pervade the engineering fraternity and ensure prosperity unto posterity.

"SARVE JANAH SUKHINO BHAVANTHu"

(Let all people in this world be happy and prosperous-Veda)

A TQM Framework for Assessing the Needs and Satisfaction of Stakeholders in Higher Education

Prof Himangshu Paul

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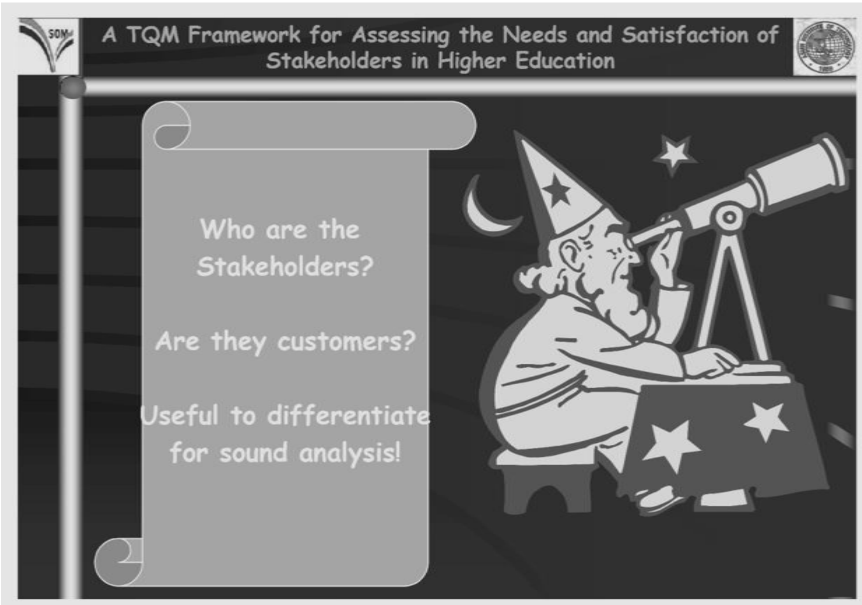
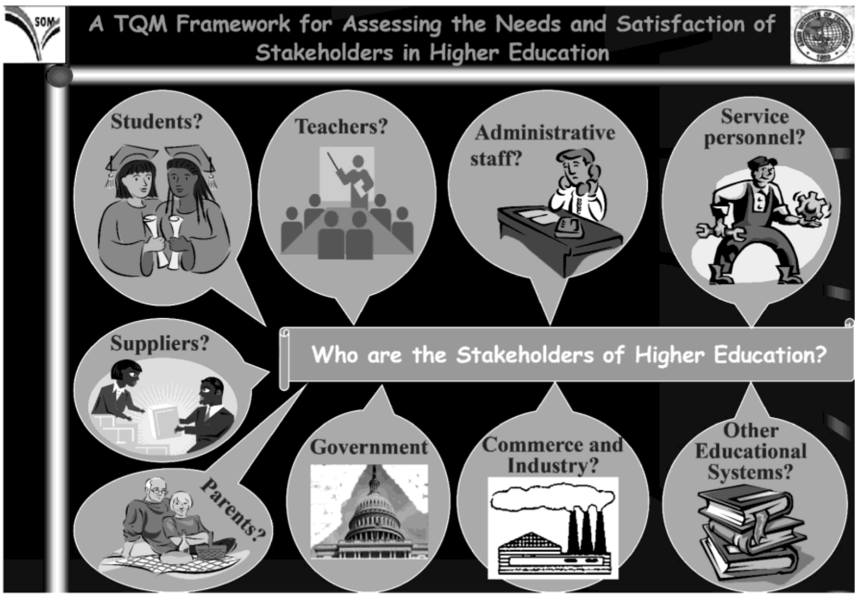
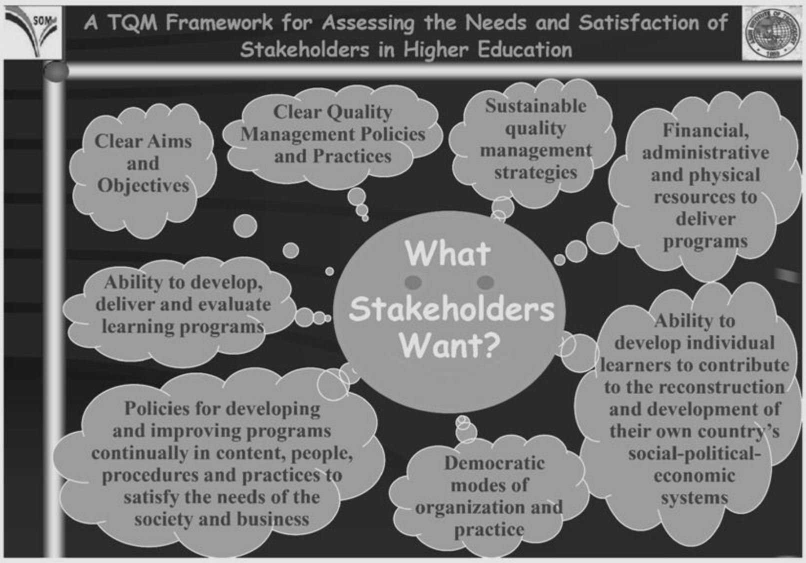
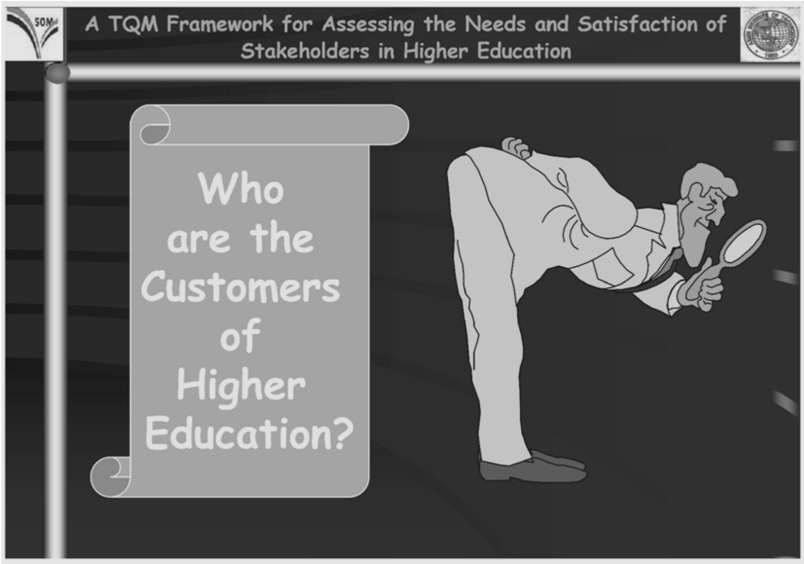
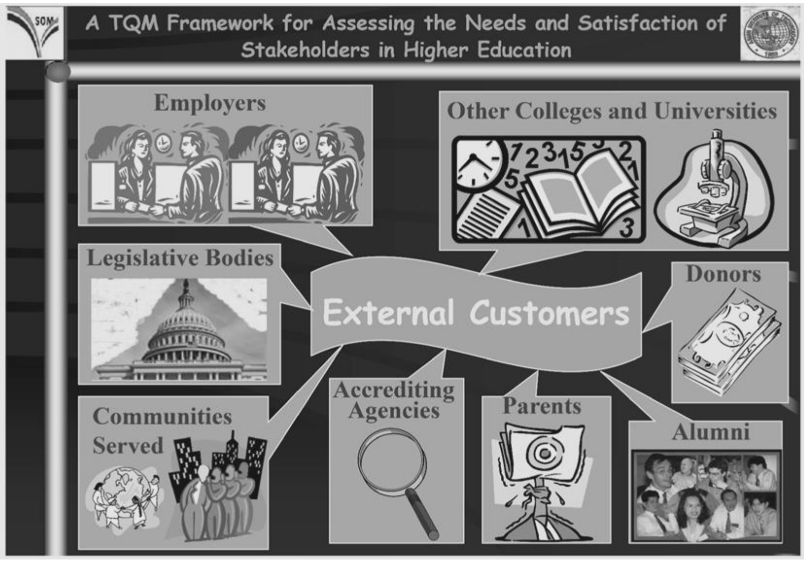
School of Management
Asian Institute of Technology, Thailand

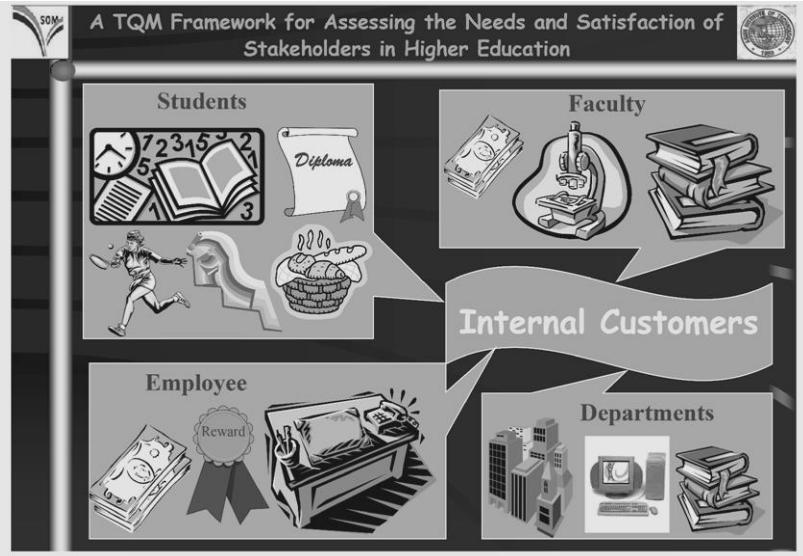


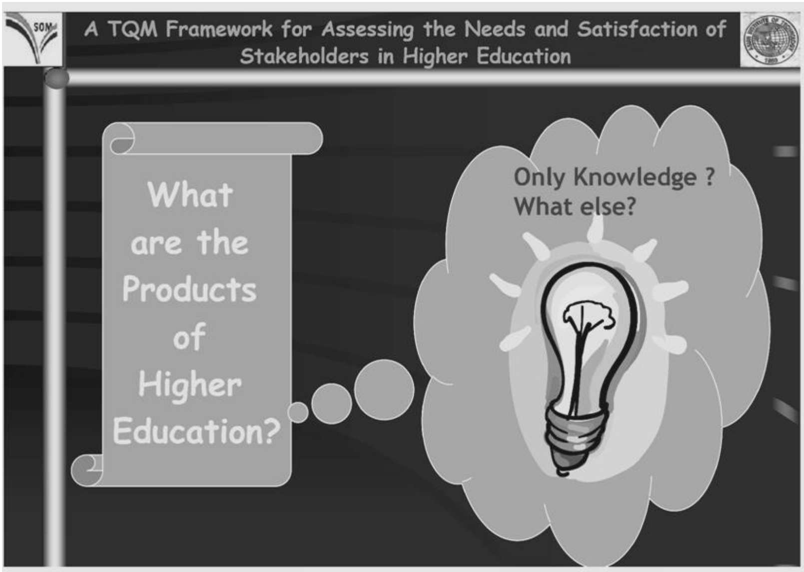


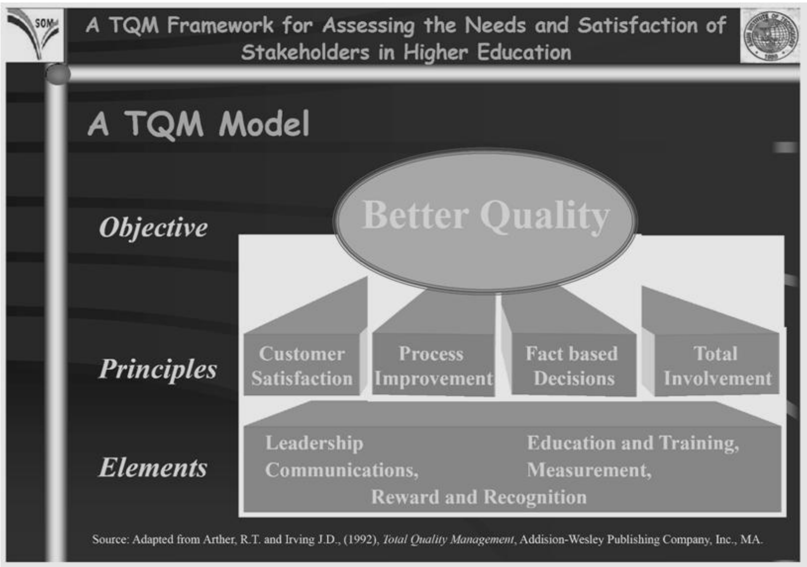

A TQM Framework for Assessing the Needs and Satisfaction of Stakeholders in Higher Education
What Stakeholders Want?
Clear Aims and Objectives
Clear Quality Management Policies and Practices
Sustainable quality management strategies
Financial, administrative and physical resources to deliver programs
Ability to develop, deliver and evaluate learning programs
Ability to develop individual learners to contribute to the reconstruction and development of their own country's social-political-economic systems
Policies for developing and improving programs continually in content, people, procedures and practices to satisfy the needs of the society and business
Democratic modes of organization and practice

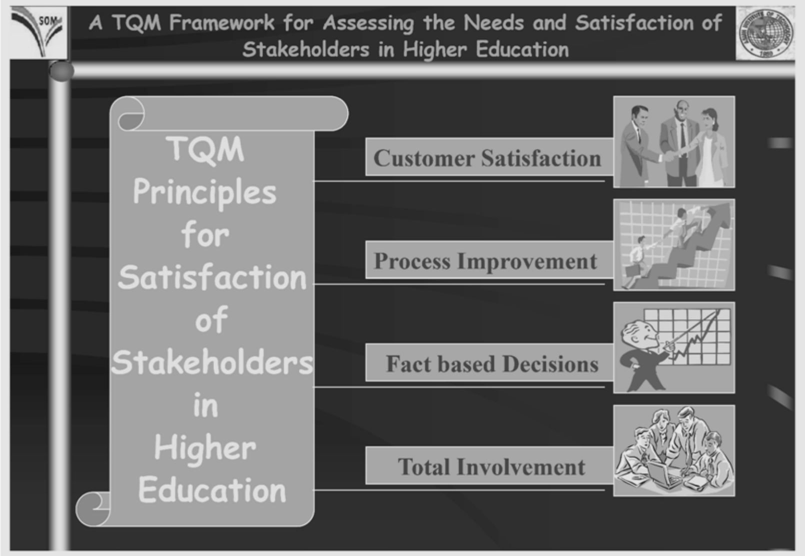

A TQM Framework for Assessing the Needs and Satisfaction of Stakeholders in Higher Education
Who are the Customers of Higher Education?

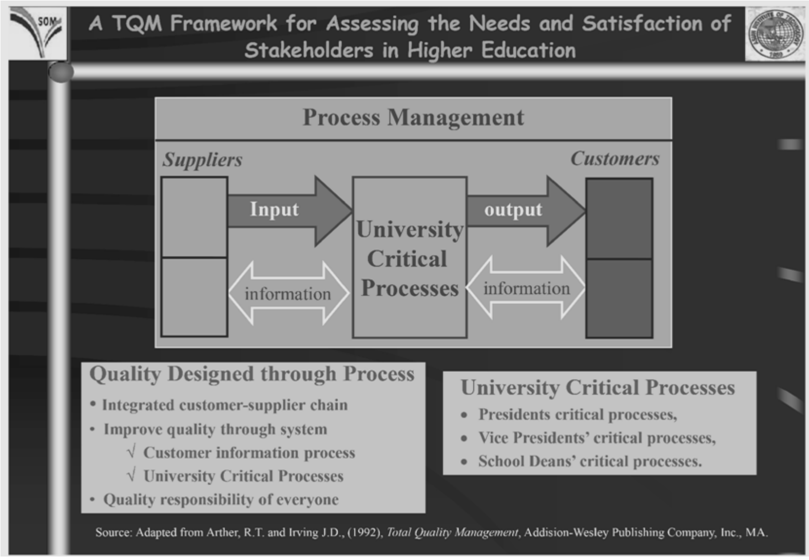

A TQM Framework for Assessing the Needs and Satisfaction of Stakeholders in Higher Education
External Customers
Employers
Other Colleges and Universities
Legislative Bodies
Donors
Communities Served
Accrediting Agencies
Parents
Alumni

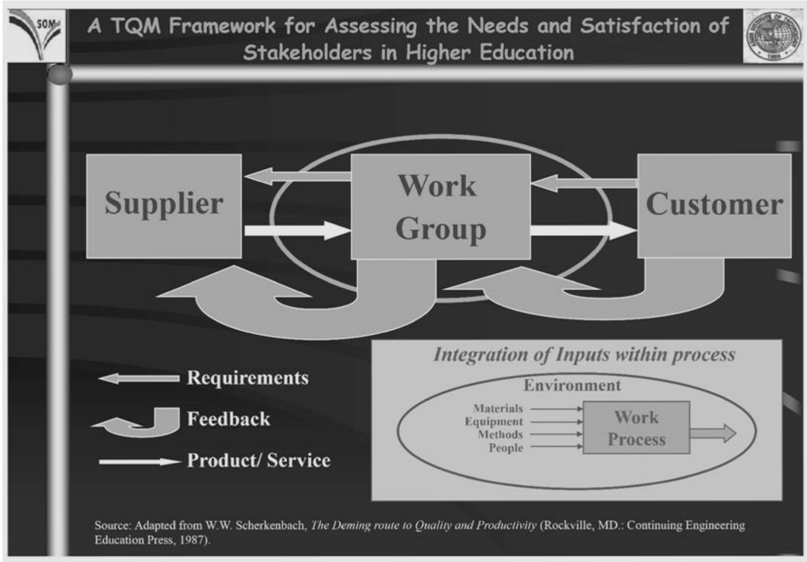

A TQM Framework for Assessing the Needs and Satisfaction of Stakeholders in Higher Education
Students
Diploma
Faculty
Internal Customers
Employee
Reward
Departments

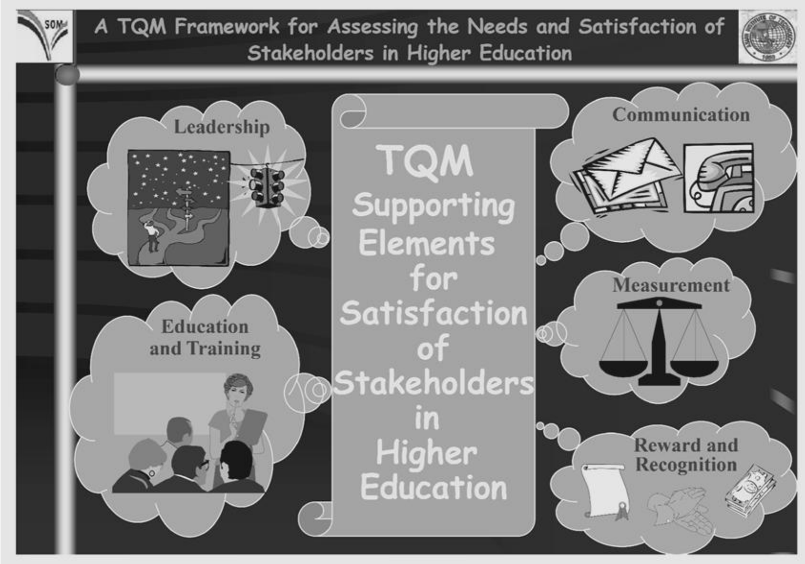

A TQM Framework for Assessing the Needs and Satisfaction of Stakeholders in Higher Education
What are the Products of Higher Education?
Only Knowledge ?
What else?


A TQM Framework for Assessing the Needs and Satisfaction of Stakeholders in Higher Education
A TQM Model
Objective
Better Quality
Principles
Customer Satisfaction
Process Improvement
Fact based Decisions
Total Involvement
Elements
Leadership
Communications,
Education and Training,
Measurement,
Reward and Recognition
Source: Adapted from Arther, R.T. and Irving J.D., (1992), Total Quality Management, Addision-Wesley Publishing Company, Inc., MA.


A TQM Framework for Assessing the Needs and Satisfaction of Stakeholders in Higher Education
TQM Principles for Satisfaction of Stakeholders in Higher Education
Customer Satisfaction
Process Improvement
Fact based Decisions
Total Involvement


A TQM Framework for Assessing the Needs and Satisfaction of Stakeholders in Higher Education
Process Management
Suppliers
Customers
Input
output
University Critical Processes
information
information
Quality Designed through Process
• Integrated customer-supplier chain
• Improve quality through system
√ Customer information process
√ University Critical Processes
• Quality responsibility of everyone
University Critical Processes
• Presidents critical processes,
• Vice Presidents' critical processes,
• School Deans' critical processes.
Source: Adapted from Arther, R.T. and Irving J.D., (1992), Total Quality Management, Addision-Wesley Publishing Company, Inc., MA.


A TQM Framework for Assessing the Needs and Satisfaction of Stakeholders in Higher Education
Supplier
Work Group
Customer
Requirements
Feedback
Product/ Service
Integration of Inputs within process
Environment
Materials
Equipment
Methods
People
Work Process
Source: Adapted from W.W. Scherkenbach, The Deming route to Quality and Productivity (Rockville, MD.: Continuing Engineering Education Press, 1987).



A TQM Framework for Assessing the Needs and Satisfaction of Stakeholders in Higher Education
Leadership
Communication
Measurement
Education and Training
Reward and Recognition
TQM Supporting Elements for Satisfaction of Stakeholders in Higher Education

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