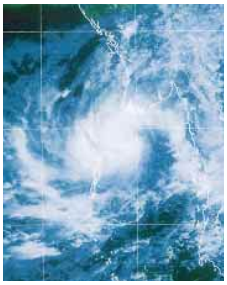

CHAPTER XXIV

ENGINEERING AND TECHNOLOGY FOR DEVELOPMENT

The Planet Earth has the unique feature of sustaining by the energy of the sun, the marvel of biological living systems. The regions of the earth close to the equator in north and south latitudes up to the transit of the sun, particularly in the neighbourhood of the oceans have the blessings of perennial rivers and other water resources. The peoples of these territories have access to extraordinary abundance of microbes, plants and animals. They meet with ease and certainty all their simple essential needs which provide them in turn the precious freedom and leisure for exploration, experimentation, speculation, creative expressions in new knowledge, languages, literature, performing arts, craftsmanship, with a variety of natural materials and tools. The leaders and rulers in these regions guided by the wisdom of empirical observations provided patronage and resources for the bold, and imaginative ventures in arts, culture, architecture and voyages to enhance sensory perceptions and appreciation as well as to create wealth and well-being of their peoples for meeting the needs of water, food, housing, clothing and ensuring health, nutrition, security, justice and much joy.

Rivers, deserts, forests, mountains, oceans had to be crossed for exploration. These necessitated evolution of engineering and technological capacities from scientific enquiries and laws of science. These were exchanged in trade and commerce and by aspirations for travel and quest. The richness and wealth of these regions in Southern Europe, Northern and Western Africa, West Asia, Coastal East Africa, Central Asia, South Asia, Asia Pacific and China have thus been the greatest originators of engineering and technology over five millennia.

These exchanges and interactions have increased substantially through greater facilities in seafaring and voyages across the Indian and Pacific oceans and the Atlantic. Thus transfer of new knowledge and materials between the Indian subcontinent, Pacific areas, China and Latin America also increased. The rich biological mineral resources and contact with the highly skilled personnel in India in design, fabrication, construction, navigation as well in complex manufacturing processes attracted attention of European powers. Thereafter interchange of economic plant materials became possible between Asia and Latin America. These regions constitute what is termed the Third World.

The great scientific advances in the past two centuries have resulted from novel engineering and technologies in energy generation and use in creation of industrial goods, services for improving health, nutrition and conquest of diseases. The Third World has gained power for self-rule and is aspiring to attain rapid economic growth and societal development. Indian developments in the past two hundred years and especially in the later half of the twentieth century have derived much inspiration and sustenance from interactions within the Third World.

Indian Enterprise

India has witnessed many developments in the past through contacts with South Asia, China, Japan, Korea, Mongolia, West Asia, Central Asia, Coastal Red Sea, Southern Europe and many countries of Africa. The languages, literature, architecture, cuisine, beverages, perfumery, textiles and garments, home implements, jewellery, paintings, crafts, musical instruments bear witness today of such engineering and technological exchanges.

As mentioned earlier, major initiatives in India by scientists and patrons of sciences have been aimed at creating capabilities and capacities for new technologies and applications for self-reliance to meet the needs and aspirations of the people. As elucidated in Section 2 India witnessed a renaissance in science and technology primarily through the vision and efforts of several dedicated brilliant scientists and their patrons. Before 1950, India had engineered production of sugar, textiles, chemicals from coal tar, pharmaceuticals, vaccines, dyes, industrial explosives and steel. Soon after Independence, guided by Jawaharlal Nehru, Mahalanobis and PMS Blackett, India launched programmes for engineering and technolgies for production of new drugs, antibiotics, machine tools, steel, non-ferrous metals, ships, aircraft and industrial control instruments. The nurturing of the Council of Scientific Industrial Research by S.S. Bhatnagar with active support from the Government formally encouraged technology generation for self-reliant economic development. These objectives are continuing to be realized by active partnership with Industry and basic sciences. Brief reviews of the primary engineering and technology generation leading to success are outlined, while taking note of the serious new concerns that have grown in the last three decades on global environment and loss of biodiversity.

THE NURTURING OF THE COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH BY S.S. BHATNAGAR WITH ACTIVE SUPPORT FROM THE GOVERNMENT FORMALLY ENCOURAGED TECHNOLOGY GENERATION FOR SELF-RELIANT ECONOMIC DEVELOPMENT.

India with a billion inhabitants perforce must promote and adopt numerous innovations in Engineering and Technology for achieving sustainable, development, recognizing the availability and limitations of its natural resources. The experience gained in meeting the needs of water, energy, food, health, housing and habitat, largely with self-generated and self- reliant technological advances in industry, services and human skills and for fulfilling aspirations in the next two decades are recorded.

Water Resources

Education and training in advanced civil and hydraulic engineering has lowered dependence on seasonal monsoon rains and melting of Himalayan snow for the rivers, through design and construction of big dams, canals and reservoirs. To a large extent floods have also been regulated. Through irrigation, arid, desert and saline lands have been greened. Remote sensing satellite technologies have been added to traditional technologies for locating ground water. New membrane technologies have enabled major chemical and petroleum industries in Chennai to flourish with only municipal waste water. Soil lining with polymer agro films of canals, storage tanks and ponds as well as cover of farm lands have curtailed seepage and evaporation losses. It is not uncommon in the fertile Punjab and Gangetic Plains to raise three crops a year from short duration varieties, benefiting from

perennial sunshine coupled with irrigation. Lined ponds have promoted fish farming on a large-scale. The desalination engineering of cooling tower discharges in petroleum, chemical and thermal electrical power generation by membrane and osmosis technology has led to fresh water conservation. Closed cycle fresh water circulation, cooled by once-through sea water in coastal region in industry is increasing. Rain water harvesting through appropriate indigeneous technologies is being introduced in many regions.

Brilliant hydraulic design engineers have, since Independence been responsible for building great dams and barrages all over the country. Rivers also are an important means of transport with bridges to facilitate their navigation. Dams and waterfalls provide hydropower. Abundance of such hydropower supported electrolytic hydrogen and alkali production. The potential for harnessing river and rain water resources is very high through appropriate new technologies. Development of small and micro hydropower equipment of high reliability is able to provide water and electrical energy to small isolated mountain communities. Such power is also stored in efficient batteries for night lighting and for hospital equipment, telecommunications, education and television in remote areas. Rural village communities in arid and semi arid zones in Western India have adopted new technologies for conservation of rain water to raise forests with fast-growing trees and shrubs for fodder, fire-wood and minor timber. Major advances in Ion exchange and membrane based technologies and highly reliable equipment have ensured safe drinking water supply at low cost in urban areas as well as in schools and hospitals. In the islands of Lakshadweep and Andaman and Nicobar and in coastal areas of Kerala, introduction of salt-tolerant varieties of crops such as rice, coconut, have been successfully employed.

The detection of presence of toxic arsenic in ground water in eastern India has prompted development to limit such sources for use by humans and livestock.

A special concern is related to water reservoir-induced seismic activity in high dams especially in the light of growing knowledge of plate tectonics on the movement of Indian Peninsular Plate against the Himalayan plate. Owing to deforestation in the catchment areas, there is a heavy loss of top soil and silting of the rivers causing flash floods and decrease in the storage capacity of the reserviors. Further, reduction in the depth of estuaries is leading to the lowering of the limits of tonnage of ocean liners in ports and harbours such as Haldia of the Ganga-Brahmaputra Delta and is receiving serious attention of engineers.

Global warming even on a miniscule level will increase the flow from melting snows of the Himalayan peaks and sea level rise in coastal regions affecting major urban centers and fishing communities. This is of special concern in the Indian subcontinent and has ushered substantial Indian scientific contributions for international studies.

Land Quality Management

The vast increase in agriculture during the fifty years has been possible through very large additions in irrigation, introduction of high-yielding varieties, use of fertilizers and pest and weed control measures. The gross irrigated land has increased from 25 to 70 million hectares. The net sown area of 142 million ha of all types cannot be further increased. The demand from urbanization, housing and industry is converting land to non-agricultural uses. There is an important need to augment the area under forests. Fresh land addition is possible only through reclamation of mined areas and unproductive lands severely affected by salinity, alkalinity and water logging. Reclamation through appropriate technologies using a consortium of microbes and plants are being developed in a few centres (see chapter on Plant Sciences) for generating forests. Engineering efforts to reclaim land from the oceans has been done for urban purposes in a few coastal areas. Other engineering and technological efforts are in progress.

Innovations in balanced use of synthetic and natural organic fertilizers, integrated pest management technologies and regulated utilization of ground water are methods being applied to ensure sustainable development. Cooperative efforts on wasteland treatments by accurate ground water surveys and computerized systems of modelling are being evolved.

The rural population of India increased from 300 million in the past fifty years to 630 million and may increase further to 700 million in a decade. With mechanization of agriculture, mining, transport and small-scale industries, employment opportunities are dwindling markedly and there is considerable migration of rural people to urban areas.

The Indian urban population has grown sharply from 50 million to 370 million in the last fifty years and may reach 465 million in 2020 with consequent demands for housing, transport, commerce, education and medicare. The planning for very large cities of 10 million and above in the decade requires innovations in engineering and technology and active cooperation with social scientists. Practical solutions are to be found to meet the needs of the migrants, maintenance of peace and of human dignity by gainful use of all citizens. Technologies are being developed for reduction of non renewable urban waste, positive use of solid waste and treated by new technologies are conserving land for sustainable development technologies for use of agro-domestic waste and carbonaceous materials for steam and power generation..

Energy

Five decades ago the country was blessed with abundance of forests. The major domestic energy needs were met from firewood and crop residues. The total amount of coal consumed was 30 million tonnes for power generation, industry, cement, brick and construction materials. The total annual consumption of petroleum products was one million tonnes, predominantly used by urban homes and municipalities. There has been an enormous increase in energy needs and use of non renewable sources. The future developmental goals are highly dependent on such energy. The quantum of these is discussed together with the engineering and technological innovations for ensuring high quality environment in land, water, ocean and atmosphere to meet international standards. The energy in India needs to grow at about eight per cent per annum for economic development with the yearly population increase of 1.7 per cent.

The ampleness of renewable resources at the time of Independence may be illustrated by the use of forest wood in Kerala for ammonia fertilizer technology and for methanol production. Even today about 50 per cent of total energy of the country is contributed by bio-mass. Hydropower was abundant five decades ago, when energy demand was not high. Hydropower is still an important source presently with a capacity of 23,000 MW. The major increases are from thermal power from coal and lignite. There is increasing demand for petroleum, oil and gas.

Technologies in Thermal Power Generation

The present installed capacity is about 100,000 MW out of which 70,000 MW are derived from coal and lignite, the balance is mainly from oil and gas sources. The addition in the next decade is likely to be 100,000 MW with 60 per cent from coal and lignite. The current annual generation is 500 billion watts. Coal in India is largely from mines in Bihar in the North and West Bengal areas. Transportation by rail to Western coastal India involves long rail transport involving energy consumption. Indian coal has also high ash content. Lignite is mined mostly in South India, Andhra Pradesh and Tamil Nadu and power generation is located close to extraction site. There are coal reserves deep underground in the State of Gujarat.

Major advances have been made in design of large size steam boilers and rotating machinery of

generators. There are efficient coal especially near mine sites where mega generation plants of capacities totalling 2000 MW had been developed. Engineering perfection has been achieved by Indian design and manufacture of all plant, machinery, electronic instruments and computer based operation controls for thermal power generation. The Plant Load Factor has been increased to 73 per cent.

Technologies developed relate to utilization of fly ash at a level of 10 per cent in cement and in the production of fly ash bricks and ceramic tiles and sanitary ware. The fly ash disposal continues to be a major concern and innovations in land filling and in mines are being attempted. Here again cooling tower water desalination and reuse are being practised. Emissions to atmosphere are controlled by treatments to reduce sulphur and nitrogen oxides to very small amounts.

Innovations in Technology

Major innovations are aimed at higher efficiency by operation to total design thermal capacities and reductions in atmospheric emissions. These are based on greater efficiency in steam generation as well as in the production of gaseous forms of fuel. Success has been achieved in pilot scale gasification and in continuous operation in small size power generation plants.

The technology of Fluidized Bed Combustion in boilers is a major step. The Integrated Gasification Combined Cycle (IGCC) Technology developed in India, produces a totally ash-free gas which is then utilized for higher inherent energy in the coal for conversion to electrical power with a consequent enhancement of power generated with the same coal from 27 to 32 per cent. Until now IGCC has been in use in a proven manner only with natural gas and not with coal. The higher capital costs are justified by increased amount of power generated from given quantity of high ash coal and total absence of particulate emmissions. Electrostatic precipitators in the present power plants have also reduced substantial amounts of particulate matter emission.

An outstanding technology has been the pilot scale demonstration of in situ deep underground coal gasification to make available gas fuel for power generation without the need to mine and lift such coal to ground level. This technology would be very valuable in the future and needs to be fully supported.

The present peak load capacity utilization in thermal Power is 95,000 MW. The energy generation increase from about 200 MW, 50 years ago is a clear indicator of economic progress. Further additions in the next seven years would be 1,70,000 MW capacity in thermal power.

Petroleum Oil and Gas Technologies

Petroleum Oil and Gas have become the dominant materials in the world during the last 50 years for the extraordinary economic growth of the Western World of Europe and North America. The discovery of oil and gas in West Asia, North Africa, Middle East and the Gulf Countries was made 25 years ago. Additional sources of oil and gas have been located in North Sea in Russia, Central and South East Asia, Bangladesh, China and in Central and South America. Petroleum and gas have become the key materials for energy for industry and infrastructure and for chemicals, fertilizers, petrochemicals, metals, new novel materials. The realization of their value to the world economy has led to generation of great wealth for several Developing Countries. Coal which served as the major source for the industrial revolution for steam, electricity has been replaced and nuclear energy growth has slowed. Coal tar, a by product in the production of coke for steel manufacture as well as alcohol from molasses in sugar making which were the major sources for chemicals, plastics and fibres have been displaced by petroleum oil and gas. Vast increases in air, ocean and land vehicle transport have resulted from increased availability of petroleum.

Major international investments have been in

research, new technology development and adoption of the technology. These new technologies are constantly adding to the creation of wealth and prosperity of the world in a manner unsurpassed in human civilization at a time of enormous increase in population. The great advances in chemical sciences and technologies of the eighteenth and nineteenth centuries and the first half of the twentieth century have been the major factors. In addition, advances in physics, spectroscopy, crystallography and electronics have created techniques and scientific instruments of extraordinary sensitivity to comprehend the complexities of chemical transformations. Geological and geophysical technologies for exploration have led to new reserves. New alloys and novel new materials are crucial in the fabrication of very large equipment for production and safe transport of oil and gas and manufacture of petroleum products and petrochemicals without corrosion and failure.

India has been able to make large strides in research and largely self- reliant technology and engineering in this sector. Oil was discovered in Assam in 1875 in a location named Digboi. Oil and gas recovery and a small refinery were established in 1933 by Assam Oil Company and these have continued to function till now. Recognizing the importance and complexity of petroleum products major international oil companies have established refineries in Mumbai, Kochi (Cochin), Chennai and Vishakapatnam. The Government of India promoted the Oil and Natural Gas Commission in 1956 and the efforts of geologists led to the discovery of oil and gas onshore in Gujarat and later in Mumbai offshore and gas fields in Northeast India . As in other sectors, Government invested in Petroleum processing and construction of Refineries in Vadodara, Barauni, Haldia with assistance from Russia and East Europe. The Indian Institute of Petroleum to carry out research and a consultancy organization Engineers India Ltd for project engineering were instituted during 1962-66. The ownership of international oil companies was transferred to the Government in 1975 soon after the major international discoveries of oil and gas and also in western India and offshore. These have led to major contributions in India in research, technologies and expansion of the oil sector and its continuation. For the first time in India, the entire detailed design, detailed engineering of equipment, civil structures, utilities, stage-wise inspection of fabrication, erection and commissioning of processing petroleum, oil gas and petrochemicals, polymers could be carried out successfully from 1975 by Indian organizations. Several thousands of engineers and technologists and others have been trained in many skills in such a highly complex venture. Research in many institutions has led to new processes, catalysts and separation technologies. They have contributed to self-reliant development in public and private sector in India and have led to major project assignments abroad. For over two decades the Oil Industry Development Board and the Centre for High Technology supported by the Ministry of Petroleum and Natural Gas. have pioneered the development of several new technologies. All the organizations involved in exploration, onshore offshore production pipeline transport, refining to high value added products as well as formulations of lubricants are meeting environmental standards. These companies and Design and Project Engineering organizations have developed high quality R&D Centres and special units for safety. These are unique to the Oil and Gas sector and have been the basis for unsurpassed success in the past 25 years and for equipping it to enter World Free Trade and Patent regime shortly.

Indian requirements of petroleum products have increased from one million in 1950 to 100 million tonnes currently. Imports are 75 million tonnes, of crude per annum and will increase to 177 million tonnes in six years using Indian technologies and Indian equipment. Large increases in petroleum refining capacity have been made in

the last 20 years. The total basic and detailed engineering, equipment selection, installation and commissioning and operation capacities have been developed in these two decades. Virtually fabrication in India of all items of complex special steel equipment, including major facilities for storage in spheres of liquefied gases at low temperatures of -170° C has become possible.

Indian organizations have successfully completed major projects on LPG, LNG and Refinery in Algeria, Abu Dabi, Iran, Iraq, Libya and have made contributions in Malaysia and Vietnam. Excellent coordinated efforts between universities, research laboratories of CSIR have resulted in generation, production and large-scale use of new catalysts, molecular sieves and technologies for meeting high environmental standards. The Refinery at Mathura, 60 km from Agra City is one of the three in the world to be recognized for meeting the ISO 14000 standard. The internal energy consumption in processing in refineries has improved from 9 to 3 per cent.

The quality of diesel has been greatly improved. Sulphur content has been drastically reduced in Indian refineries initially to 0.25 per cent. In the near future, enhanced hydro desulphurisation technology would lead to very low levels of emission from automobile transport and power generation to the atmosphere. The aromatics content of diesel in naphtha and petrol has also been reduced to eliminate benzene.

Capabilities for exploration, offshore production of crude oil and gas, design, fabrication and installation of offshore facilities are now well-developed as also for sub-sea pipeline transport. Total technology and engineering has been accomplished for LPG production two decades ago. Major technologies have resulted in high recovery of distillation products, gases for petrochemicals, polymers, microcrystalline wax and high value products. India has outlined a Vision for 2025 for the Oil Sector and has committed for free trade in petroleum products from 2002. Engineering and technology as well as skilled human resources have created confidence for international competitiveness.

Crude production in Western onshore and offshore and to a small extent in the North East is declining from a peak of 35 to 26 million tonnes. Exploration has been intensified. India will be a major importer of Oil and Natural Gas from several countries, including those in the Third World. There are very high potentials for cooperation in engineering and technology to meet ideals of conservation, environmental quality and innovation.

Nuclear Energy Technologies

The self reliant advances in technology for generation of Nuclear Power have been mentioned elsewhere. The remarkable achievements are in design, fabrication, installation of equipment, production of high quality fuel materials such as Uranium 238 from Indian uranium ore sources, heavy water from ammonia fertilizer plants, especially using hydrogen sulphide utilized in the indigenously designed power reactors. Technology is being generated for large future investment in Fast Breeder Reactors, based on thorium from abundantly available Indian ores. The current Nuclear Power Generation capacity of 2720 MW is expected to double shortly. Nuclear Power will continue to be an important source of energy in the country.

Electrical Power Transmission Distribution Technologies

India is a country of vast distances with coal resources confined to one area. Transmission losses in electricity in the present technology are estimated at 15 per cent. A technology for more efficient transmission has been developed and demonstrated in High Voltage Direct Current (HVDC) in place of relatively Low Voltage Alternate Current for long distance. This innovation is of great significance in plans to evolve an efficient management through Regional Grids and eventually a National Grid.

Technologies for Power from Renewable Sources

The technological advances from renewable sources are to be found in this volume in Chapters on the Ministry of Non-Conventional Energy Sources, Department of Biotechnology and Department of Ocean Development.

Technologies for Solar power with Indian Amorphous Silicon Panels, as also from Indian Wind Farms have been demonstrated. An attempt to use ocean wave energy has been made. Proposals for ocean thermal energy conversion are under consideration. Community biogas generation from rural wastes from livestock has been demonstrated. In the early years, biogas generation was found to be low during winter months in north India. New genetically engineered microorganisms for higher efficiency in conversion capacity to perform at low temperatures with assurance of year-round generation are yet to be evolved.

Metals and New Materials

Technological advances in steel have led to production of high strength alloy steels. Copper, zinc and lead are produced efficiently in the country. India has very high reservoirs of Iron ore and bauxite. The country is a major producer of aluminium and has also developed technologies for the high strength special aluminium alloys essential for aircraft. Indian bauxite and aluminium production are in a position to yield a large amount of the very valuable metallic element gallium. Technology for high quality gallium has been evolved on a pilot-scale and can be readily adapted for large-scale. Gallium arsenide has considerable potential in the electronics and related industries.

There is wide special knowledge and new technology available for the development and production of numerous catalysts using nickel, cobalt, palladium, selenium, silicon, ruthenium, copper, rare earths for applications in the oil, gas, chemicals, fertilizers, drugs, polymers and fibre industries. There are also excellent technologies for fuel cell power and high efficiency power storage batteries, photovoltaics and devices for controlling automobile exhaust emissions. These arise from basic knowledge in metallurgical science, microanalysis spectroscopy, crystallography, solid state chemistry and condensed matter physics. Many major advances in energy conversion, storage, controlled usage are in need of such knowledge as also photography and communications.

There have been notable achievements in the production of liquid crystals carbon fibre, composites, engineering polymers, optical glass, amorphous silicon photovoltaics, special starches, modified celluloses, membranes, special absorbents and gelling agents.

Communications Technologicals

The vastness of the country with a billion people, using over a hundred languages and other dialects, fifteen officially recognized written languages, pose many technological challenges in communication. Great success has already been achieved in telecommunications, television, satellite development, orbit placement and usage. The educational system has expanded vastly with common syllabi, qualifying examinations. The democratic system, the legal and justice administration rely on transparent and rapid communication, computerized storage and retrieval with simultaneous automated translation. The Union of India with its parliamentary system and constitution has succeeded immeasurably among the newly Independent countries in the developing World.

The Indira Gandhi National Open University with nation wide higher education network is an outstanding testimony to the success of the communication technology.

The role of the communication system in the documentation of the enormous cultural creativity in rural and local handicrafts, mutitude of technologies in handloom, dyeing, metal forming, casting, pottery, ceramics, moulding as well as in

several thousands of celebrations of festivals, music, dance, performing arts has been invaluable. These have encouraged tourism, trade, commerce, horticulture and cooking. India is the country with the world's largest growth in telecommunications, technologies, devices and for innovations yet to emerge.

Technologies for International Trade

India has had a long tradition of multifarious designs and preparation of textiles and garments by hand craft in different parts, using local raw materials such as cotton, jute, wool, linen and other plant materials and silk. The extraction of pigments and fibres, spinning, weaving, dyeing and printing techniques were innumerable and characteristic of the subregion. They were important in preserving individuality and excellence. Special textiles and garments were made for celebration of festivals, birth and marriage ceremonies, dances, performing arts and as offerings. Looms have many variations and designs and are run by notations based on complex mathematics and engineering technologies. In some instances the making of a garment or *saree* and weaving of carpet takes a few months. Specially light wool fabrics are woven from the under-fur of goats such as angora and pashmina native to the mountain peaks of the Himalaya. These are highly valued internationally and fetch high prices. The importance of these native for the economy of each rural center was long recognized and Mahatma Gandhi symbolized the spinning wheel for handmade cotton yarn *khadi* and the homespun cloth *khaddar*. The related products of ceramics, pottery, bamboo and cane wickerwork and of incence, honey, flavours, perfumes, bronze, stone, marble objects, musical instruments have become the core of khadi and village Industries. The crafts tradition is a vital force. The first President of India, Rajendra Prasad was drawn to the Freedom Movement by the plight of the farmers in Champaran, Bihar, who were producing the plant derived dye Indigo by competition from low-priced imports of synthetic coal-tar based dyes from Europe. Laksha from the lac insect (laccaic acid) and alizarin obtained from madder root are valued reddish dyes. The chemistry of natural colouring matters has engaged the attention of numerous renowned scientists of Europe and several Indian scientists notably T R Seshadri and K .Venkataraman. There is now a worldwide demand for textiles prepared with natural dyes and total absence of synthetics. Modern technology is being incorporated into the rural Centres to increase productivity, reduce arduous labour and to enlarge the range of products in demand. The National Institute of Design, Ahmedabad has pioneered new designs and has trained highly qualified engineers to provide assistance to the weavers and other artisans.

Items such as handcrafted jewellery made of precious and semi-precious stones in myriad traditional designs, ethnic jewellery made of anodized silver and other metals, bangles made of bone, ivory, wood and glass offer a wide range to tourists and markets abroad.

Likewise access to a primary need, namely salt was also chosen symbolically by Mahatma Gandhi for ensuring the right to make salt for essential family use. Another basic material in village economy, skins and hides from the vast animal population were prepared by a particular section of the rural community. Mahtma Gandhi elevated them to be valued members of the society. Processsing of raw hides to leather and leather goods using vegetable tannin materials is an ancient technology. Leather products are in high demand for local use and export. The application of innovative science and technology by the Central Leather Research Institute (CLRI), Chennai have eliminated virtually all toxic and environmentally unacceptable chromium from effluents. Nayudamma and his successors at CLRI has played a crucial role in leather industry with excellent design, footwear, bags and leather goods form major export items from India.

The import of cotton fibre and textiles from Europe invited opposition of the Indian Cotton

Mills who also became major patrons of self reliant development and supported Indian research widely. The cotton industry pioneerd the production of industrial starch and expanded it for .preparation of glucose and industrial enzymes in Ahmedabad and Coimbatore in South. The expertise and valuable experience gained promoted investment in fermentation technology for antibiotics and drugs. Similarly, the Indian cotton mills industry made investments in rayon and later to nylon, polyester, acrylic fibres.

Other major rural agricultural and forest products have been significantly improved through food technology initially for preservation at low cost and increasingly to manufacture highly value added products in food, spices, tea, coffee, cocoa, flavour and perfume concentrates, wines, medicinal products and pharmaceuticals. The large investments for economically profitable products involve high technology including super critical carbon dioxide extraction in maintaining quality, improving the genetic varieties of sources of raw materials and ensuring supply for sustained manufacture for Indian markets and export.

Engineering and Technological Capability

Independent India, valuing the need for economic development soon after Independence arranged to send in 1946 and 1947, 600 engineers and scientists to Europe and North America for periods varying from 2-3 years to be specially trained in chosen fields of engineering and technology. The fields included coal, mining , metallurgy, chemical, engineering, instruments, machine tools, foods, fermentation, glass, ceramics, textiles, leather, reservoir engineering. building and road construction technology, cement, aeronautics, ports, harbours and naval architecture. These persons returned to India and became pioneers of many new technological research institutions. The foundation of Industrial research institutions with government support in partnership to industry was another major step. The process was extended to Electronics, Electrochemicals, Scientific Instruments and Petroleum. Biotechnology, Molecular Biology and Microbial Technology have been added in recent year.

The Government of India has also supported the growth of technological services in Indian standrads and engineering Design and project Consultancy. These are now available for innovative areas such as software, testing for quality, Medical diagnostics. The Consultancy Development Centre with several hundred consultancy organizations has generated opportunities worldwide for services in health, medicare, technological education, environment as well as in international financial development institutions and United Nations Organizations. Technological capabilities developed in the government-owned industry and other institutions form the base for the new non-Government ventures in India and internationally in the new era of knowledge based on economic development

Engineering and Technology for sustainable development of the World and especially the Third World is fundamental for the advancement of human civilization with harmony and peace while preserving the diversity of cultures.

The Golden Jubilee of your Academy comes within a year of the Silver Jubilee of the Scientific Policy Resolution. I should like the Academy to examine to what extent science and technology in India have been decisive agents of dynamic and beneficial change. Every institution must renew itself and be constantly thinking of its work in the future. Members of the Academy, so much more than others, are in a position to understand the implications of the development in science, to educate public opinion and to advise Government.

- Indira Gandhi
From her inaugural address to the
Golden Jubilee Celebrations of the Academy, 1984