THE EIGHTH
Vikram Sarabhai Memorial Lecture

on

TECHNOLOGY AND DEVELOPMENT

by

Mr. L.K. Jha
Chairman,
Economic Administration Reforms Commission

on

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Mr. L. K. JHA

Mr. L.K. Jha educated at Banaras Hindu University and later Trinity College, Cambridge he studied Economics under such distinguished men like Keynes, Robertson, and Pigou. He joined the Indian Civil Service in 1936. After serving for four years in Bihar, he came to the Central Government in 1942. The posts he has held include those of Chief Controller of Imports & Exports, Joint Secretary (Commerce & Industry), Secretary, (Heavy Industries) and Secretary (Economic Affairs), Shri. Lal Bahadur Shastri appointed him as Secretary to Prime Minister and he continued in that capacity with Smt. Indira Gandhi till 1967, when he retired prematurely from the ICS in order to become Governor, Reserve Bank of India. After three years as Governor, he went as Ambassador to USA where he represented India during the difficult days of Bangladesh crisis. From July 1973 to February 1981, he was Governor of Jammu & Kashmir. Presently he is Chairman. Economic Administration Reforms Commission

He has in the past chaired various committees set up by the Government of India to deal with diverse subjects like Development of the Automobile Industry, Promotion of Tourism, Foodgrains Prices and Indirect Taxation. He has served as Chairman of a number of international bodies and committees, such as the GATT, the Interim Coordination Committee on International Commodity Arrangements, the Corporation set up by the Secretary General of the United Nations and the Team of Industrial Experts set up by the Commonwealth to recommend ways of accelerating the industrialisation of the less developed countries of the commonwealth. He was also a Member of the Independent Commission on International Development Issues under the Chairmanship of Mr. Willy Brandt. He was a member of the Indian prime Minister's delegation to the cancun summit.

He has to his credit a number of publications on economic topics including " Economic Development : Ends and Means" "Shortages and High Prices—The way Out", and "Economic Strategy for the "80s".

Dr. Vikram A. Sarabhai demonstrated in his life his conviction that the end of all scientific endeavour was peace, prosperity and creativity. His vision of human society complemented his concept of holistic science. He used the tools of physical sciences but spoke the language of social sciences. Every activity he chose to initiate and every institution he created was of profound significance for a developing society and into every one of his endeavours, he breathed the rigour of a dedicated scientist and the sensitivity of a humanist. That his laboratory enveloped the entire community was amply demonstrated in his pioneering the management movement and applied industrial research.

One of the many institutions which had the good fortune to be touched by Dr. Sarabhai's dedicated spirit was Ahmedabad Management Association. He provided in leadership ***to AMA for the first four years as the President. AMA in*** *its gratitude elected him as the first Honorary Member of the Association.*

Today, to bring into the lives of Indian men and women the light of his spirit, the message of his life and fuller understanding of the nature of human existence, the Dr. Vikram A. Sarabhai Memorial Lecture is dedicated to his memory.

DR. VIKRAM A SARABHAI AMA MEMORIAL TRUST

Objectives

- To perpetuate the memory of the late Dr. Vikram A. Sarabhai.
- To encourage Indian men and women to emulate in their own lives his dedication and perseverance towards human betterment.
- To honour men and women who, by their own efforts and application, make significant contribution to society combining with a far-reaching humanist vision the rigour of the scientific method with the skills of organization and implementation.
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TECHNOLOGY AND DEVELOPMENT

by L. K. Jha

I feel very honoured by the invitation to deliver the Vikram Sarabhai Memorial Lecture this year. Vikram and I had been friends for years. As a Member of the Atomic Energy Commission, which he chaired with such distinction, I also had the privilege of working with him. One of the important missions on which he and I had been engaged, was to put forward an alternative to the Nuclear Non-Proliferation Treaty. Together we went to the U.S.S.R. and the U.S.A. to urge that the way to prevent proliferation of nuclear weapons was not to pressurise non-nuclear powers to sign a discriminatory Treaty, which would come in the way of their using nuclear energy for peaceful purposes. Instead, the problem should be viewed from the strategic and security angle. A country may want to acquire nuclear weapons if it feels threatened by a nuclear power, or if it wishes to pose a nuclear threat to another country. If the two super-powers made a joint declaration that if any non-nuclear State was threatened with nuclear weapons, they would jointly and severally come to its immediate assistance, there would be a dramatic change in the strategic balance. Non-nuclear countries, which felt that they might be exposed to a nuclear threat, would feel more secure, while those countries which aspired to indulge in nuclear blackmail would be effectively deterred.

I must in all humility say that the basic idea essentially was his. My role was to develop it in some detail for purposes of presentation, first to our own government and

later, at the highest levels in Moscow and Washington, and subsequently in London and Paris. This is not the time or occasion to go into the responses we had-which were by no means negative-and the hurdles, which ultimately blocked progress. I recall this event to illustrate the versatility and brilliance of Vikram Sarabhai's mind. He contributed new ideas in a very wide variety of areas. However, since he is best known as a man who combined business acumen with scientific talent, I feel that, as a topic for a lecture in his memory, I might choose "Technology and Development". This was a field in which we were both actively involved-he as a scientist promoting the growth of technology and I as an administrator concerned with economic development.

Vikram Sarabhai's untimely death at such a young age was indeed a national loss apart from the loss suffered by his family and friends among whom I am proud to count myself.

It has become customary to speak of science and technology in the same breath as if they were necessarily inter-connected. Such an impression has been created by the many technological leaps. which are attributable to discoveries made by science. The discovery of the steam engine led to the Industrial Revolution-Electricity and electronics, petroleum and petro-chemicals, computers and robots, as and when scientists discovered or created them in their laboratories, have imparted new impulses to the processes of production opened new vistas of consumption.

Yet, it is important to remember that the human race embarked upon its quest of technology long before it began to take an interest in science. Primitive man, in his struggle for survival against the more ferocious members of the animal kingdom, relied more on his brain than on his brawn.

He began to fashion tools with which to hunt, to cultivate and to build shelters. He used flint stones to light a fire. He invented the wheel to lighten the burden of transportation. Through these and other devices, he could command and control a much larger share of nature's bounty, creating wealth and adding to his material well-being.

The pace of such progress was not uniform. In some societies, conditions were conducive to quicker advance. In areas where climatic conditions and soil suitability helped the cultivation of rice, the quest for food ceased to be the sole occupation of the people fairly early in human history. They had enough leisure to devote time to cultural activities, to music and dance, poetry and literature religion and philosophy. In the rice belt of the world -Greece, Egypt, Iran, India and China-the earliest civilisations came into existence.

In countries, where tougher conditions prevailed, for many more centuries, the struggle for survival left little time for cultural pursuits. For them, the break-through came with the cultivation of wheat. But life continued to be arduous. Severe snowy winters drove them on to renewed efforts to make life more comfortable. The pace of their technological advance continued to gather momentum. Eventually, in material well-being, they far outstripped the once-affluent seats of culture. Their progress in the scientific field gave an added impetus to their technological advance, particularly after the industrial revolution.

But even when the contribution of science to technology was on the increase, many new technologies were being evolved out of work experience in the factories. Those working at machines could find ways of improving their performance. Many of the new techniques did not call for new equipment, but changes in the way that the production schedule on the shop-floor was organised, increased prod-

uctivity. Many technological advances were spearheaded not by scientists in laboratories but by managers and operatives in factory sheds.

The thought I am trying to project is that while, undoubtedly there are vital organic links between science and technology, some of the most rewarding techniques have been evolved out of purposeful pragmatism, rather than by scientific research. The point is well expressed in the "Penguin Dictionary of Economics", which defines technology as "the sum of knowledge of the means and methods of producing goods and services". Continuing, the "Dictionary" says :

> "Technology is not merely applied science because it often runs ahead of science—things are often done without precise knowledge of how or why they are done except that they are effective. Early technology-craft skill-was almost entirely of this sort. Modern technology is increasingly science based, however, and rather than relying on acquired skill, is easily communicable by demonstration and printed material to those qualified to receive it. It also includes methods of organisation as well as physical technique."

If we look back on the history of technological advance, we can discern three phases. In the earliest phase of technological progress, science had little role to play. In the second phase, technology was emerging as a by-product of science. Research done in universities and academic institutions to advance the frontiers of knowledge was being used for the pursuit of profit by those who saw the commercial possibilities, or the technological content of each new scientific discovery. Presently, particularly in the western world, mainy what are known as the multi-national corporations but even in other enterprises, more and more research is being undertaken by industry

itself to discover new methods of production to lower costs, to economise on capital, or labour-or both-or to bring to the market wholly new products to satisfy consumer needs. Indeed, many of the new products, which are minting money did not satisfy a felt need, but gave birth through techniques of advertising and salesmanship to new needs. All too often, in the present-day world, invention is the mothor of necessity and not necessity the mother of invention as in the past.

If we look at the level of prosperity-or poverty-in different countries of the world to-day, there seems to be a clear co-relation between technology and national income. Technology is the most powerful single factor explaining the differences in the wealth of nations. Yet, surprisingly the early economists did not identify the crucial role of technology in economic progress. Land, labour and capital were the three factors of production, on which they focussed attention. Land stood for natural resources as a whole, including forests, minerals, water-supply and fertility of the soil. Labour, likewise stood for the effort put in by all those who worked for the wages and salaries they got. Under the classification of capital, came the tools and the machines, which raised the productivity both of the natural resources and of the manpower, as well as the finance needed to build or buy the machines.

But, all the three factors were really the inert and passive ones: the dynamic elements to give a new impetus to economic growth was the technology though not identified as such-embodied in the machines and the methods of production, which were marshalled by the entrepreneurs. One reason why economists did not focus on technology is perhaps because that they thought that the discoveries on which new technologies were based, were accidental. They treated

technology as an exogenous factor, not influenced by economic forces or motivation. If economic decisions could not influence the growth of technology, there was no reason why economists should take notice of it.

One consequence of the neglect of technology as a factor contributing to growth was that when immediately after World War II, as one country after country began to emerge out of colonial status to full political sovereignty, the literature dealing with the problems of developing countries, as they came to be called, picked on the shortage of capital as the main obstacle to speedy growth. Not much could be done about land or the natural resource endowment of any country. Of labour, most developing countries seemed to have in abundance, though its quality could be improved by imparting the requisite skills. But the shortage of capital was much more difficult to overcome. Capital formation depended upon the level of savings. A coutry with low incomes had low savings perpetuated low incomes. This was the vicious circle of poverty. as Nurske described it, in which the developing countries were trapped.

Not unnaturally, therefore, most developing countries including India, when they embarked upon plans to develop their economies and speed up the rate of growth, concentrated on ways to increase the availability of capital. Rersource mobilisation-often treated as synonymous with taxation-became the main point of concern. Each plan became essentially an investment plan. In comparing a new plan with a previous one, the volume of the investment often became the sole yardstick. If in any one year, there was no sizeable increase in Plan outlays, it earned the epithet of "Plan holiday" from journalists, politicians and even economists.

So deep has been the preoccupation with the volume of investment that often the returns, which these investments

give, tend to be forgotten. And those who speak of the return, think much more of the financial return in the shape of profits than of the output of goods and services which the investment generates. One of the sad thnigs about the present plight of the Indian economy is that though we have, through heroic efforts, raised the level of savings to above 20 per cent of national income, which is comparable to the achievements of countries far richer, there has been no corresponding step up in the rate of growth. While a couple of decades ago, we needed approximately 3 units of capital to get one unit of output, to day we need something like 6 units of capital to get one unit of output. In the language of the economists, this means that the capital output ratio has deteriorated. This diagnosis is nothing more than a re-statement in somewhat pedantic language of what has happened-and not an explanation of why it has happened.

I believe the real reason for the decline in the productivity of capital is that inadequate attention has been paid to technology. Here, let me once again make it clear that by technology I am not referring only to the application of latest scientific discoveries to the process of production. I have also in mind such factors as organisation of production, maintenance of plants, motivation, education and skills of workers, all of which form part of the technological instruments to get more output from investments made,

In emphasizing the role of technology in maintaining the efficiency and maximising the contrbution of capital in the productive process, I derive some support from the works of eminent economists including some Nobel Laureates. Long ago, Karl Marx had predicted the demise of the bourgeois system on account of the diminishing productivity of capital. It is now accepted that Karl Marx was right in his premise, As Peter E Drucker puts it, "Left to its own devices, any economy will indeed move toward steadily diminishing productivity of capital. The only way to prevent it

from becoming entropic.....is the constant renewal of the productivity of capital.....through moving resources from less productive into more productive employment. This, therefore, makes technology the more important", he concludes, as an economy develops. From the empirical and theoretical work done by economists like Kuznets, Boulding and Denison, we now know that differences in the rate of growth in different countries are attributable not just to the rate of capital formation but much more to technological factors, the efforts made to increase the productivity of capital.

In Indian coditions much of the technological weakness which results in reducing the productivity of our most scarce resource, namely capital, arises from some mistaken policies of a regulatory nature imposed in the authorities, failures on the management front and inadequacy of innovative change in the methods of production. Even capital intensive industries are set up without adequate attention to the economies of the scale. While one large plant would have used much less of capital for the desired output and resulted in cheaper products for the people, in a laudable but misguided attempt to promote regional development the capacity is split up into small high-cost units to be located in different parts of the country. Managerial effort is often directed towards displacing labour by capital, when in our conditions the reverse should have been aimed at. And then there are the deficiencies in the technology of production itself, the tools. the raw materials and the methods which are employed, which retard progress. And it is on this last factor, the backwardness in science-based technology, its causes and remedies on which I propose to concentrate for the rest of this lecture.

Time and again, we have taken justifiable pride in having the third largest number of scientific and technical personnel-next only to the two super powers, the U.S.A. and

the U.S.S.R. The question, therefore, arises why nevertheless we seem to be lagging behind so many countries in the technological field. I shall first discuss one of the explanations which is often put forward among others by the scientists themselves. They often advance the argument that what is holding back technological progress and retarding technological self-reliance is that import of technology is being allowed too liberally. According to this school of thought if this policy was reversed, Indian scientists would get the opportunity they need to prove their mettle and contribute to the nation's technological advance.

I must say at the outset that I have every sympathy with the scientists who are voicing their sense of frustration when they complain of our continuing reliance on imported technology, but I must also add that I have the most serious misgivings about the line of reasoning which is advanced and the solution which is propounded.

A priori the view that stopping import of technology is essential for developing self-reliance in technology seems to be based on a confusion of cause and effect. Self-reliance reduces imports; but stoppage of imports cannot produce self-reliance, only shortages. If when our food production was below our requirements we had stopped importing foodgrains, we would not have become self-supporting; there would have been under-nutrition and starvation. A widely held view in the early 70's that import of foodgrains would somehow be a humiliating experience led to delayed importation, which resulted in our paying much higher prices for the imported grain and also added fuel to the flames of inflation at home.

Looking at the question empirically, I know of no country which has used a ban on imports of technology to promote technological self-reliance. Even the two super powers, for all the progress they have made in the techno-

logical field, are avid importers of technology from each other. What they are restrictive about is the export of their technology. And when such resrictions are imposed, the country to whom export is denied makes every effort to get at the other's technology by hook or crook.

Perhaps the most outstanding example of a successful technology policy adopted by any country is provided by Japan. It made a conscious effort to gain access to the latest technology developed in any country in the world in order to make Japanese products more competitive in the world markets, not on account of their cheapness but on account of the excellence of their quality. But import was not the end but the beginning of the story. The imported technology had to be improved upon to make Japanese products superior to what other countries had to offer. So today in cameras and optical instruments, in electronics and in automobiles and in a wide variety of other industries, Japanese products and the technology that goes into them have a much higher ranking than the manufactures of countries whose technology was originally imported by Japan.

The lesson we have to learn from the experience of other countries is that while they maintained a liberal import policy towards technology, they took steps to ensure that the technology, which was imported became the starting point for research to improve upon it even to make it outmoded. What we need, therefore, is attention on the ways in which indigenous technology can be developed-and used -instead of looking upon the import of technology as the enemy of progress. The progress of science has been based on a free flow of knowledge across national frontiers. Scientists in different countries look upon each other as comrades in arms and not as adversaries. Because technology has an economic use and a price tag and also because it has a role in defence strategy, its flow is subject to various

restrictions. But I do believe that scientists should favour a liberal import policy for technology, not oppose it. May I in this context also point out that while there are talented scientists in India whose capabilities are not being put to full use, thousands of our scientists are thriving in countries where the import of technology is free from any restrictions.

Two other objections from an economic point of view are often advanced against the import of technology. There is the question of the foreign exchange expenditure which is involved. And there is also the argument that new technology would aggravate the unemployment problem because most modern technology is capital-intensive.

The payment for technology is seen as a drain on our foreign exchange reserves. Here again, I venture to think that the logic employed in the analysis of the situation is faulty. Every product which we import, has a technological content. When we import plant and machinery or drugs and medicines, the most costly element in their pricing is the technology, which is incorporated in them, not the metals or the chemicals used in their production. If we can get the technology itself, then we can involve our own labour and use our own metals and chemicals in setting up the production at home.

It makes no sense to permit the import of a product on the cosideration that it is better than what we make at home, and to object to the import of technology, which would help the domesfic manufacture of the more sophisticated article. There are known instances where public sector plants lose orders, both at home and adroad, because the products are technically not as good as they should be, and yet there are protests against their being allowed to import technology.

We must of course do the utmost to conserve foreign exchange by reducing imports. In any scale of priorities for

imports, finished products must be placed at the lowest level. It is much better to import capital goods and raw materials than the finished product. If we can produce the capital goods ourselves, so much the better. If in additon we can find indigenous substitutes for the imported raw material, we advance even farther on the road to self-reliance. But the very process of import substitution, of finished goods, capital goods and raw materials requires increasing use of technology. Therefore, to the extent possible, we must prefer the import of technology to the products of technology.

The trade in technology and know—how is one of the fastest growing items on the global scene, rising from 2.7 billion dollars in 1965 to more than 11 billion dollars ten years later. Even more significant is the fact that nearly 90 per cent of this trade takes place between the developed countries themselves. In the mid—70's, only 3 countries—the U.S.A. France and Great Britain—were net exporters of technology. Countries, such as West Germany, Japan and Sweden on the other hand, spent much more on importing technology than they earned by exporting it. But the significant fact is that countries, which had a negative balance in the trade in technology, fared far better in the export of the products of technology and had a much more comfortable balance of payments position in consequence.

Thinking on the subject of the payments we make for the Import of technology, gets confused by the fact that we take into account the cost of technology, which is imported as such, and ignore what we pay out for technology whose price is included in the price of the finished products for import. For any judgement about the reasonableness of the amount spent on the import of technology, it is no use looking at the figure in isolation and expressing horror as some people do. Account must also be taken of the total amount of production generated in the country, which saved on imports of finished products as well as

the export earnings, which the imported technology made possible. A study brought out by the U.N. Centre on Transnational Corporations of the amount spent by different countries—developing and developed—on the import of technology, shows that India's expenditure is a tiny fraction of what developing countries like Brazil and Mexico, and developed countries like Germany and Japan spend.

This does not of course mean that there can be something like an Open General Licence for the indiscriminate import of technology. If we can do without a product and if it is not permitted for import any outlay on the import of technology for making it, does represent a net out-flow of foreign exchange, because there would be no off-sitting saving on the import bill. The import of technology in such cases, would have to be exceptional, primarily on the consideration that it will open up new avenues of export.

If countries like Singapore and Hong Kong have built up a tremendous export trade entirely on the basis of imported technology, making fairly extensive use of Indian technologists and technicians among others, I have no doubt that we could have done something similar from Indian soil. It has often been said that for a country like India, export-led growth is not the right answer. Of course, it is not. Our growth process must cater to an uplift of the living standards of the masses. But in our export strategy, in improving our balance of payments in getting more value for the products of our soil, a selective import of technology can make a significant contribution particularly, if, with our own research, we can improve upon the technology we import as the Japanese have always done. Let me give one concrete example. Quartz watches have been in the world market for a whole decade now. We imported neither the watches-except through smuggling-nor did we import the technology. This did not enable quartz watches to be produced by indigenous technology. Recently H.M.T. has had

to enter into a foreign collaboration to produce these watches. In the meantime, so many developing countries have done roaring business in the export of such watches.

Finally, from the employment angle, I shall offer only a few brief comments. Not all technology is of a labour-saving character. Technological advance can raise the productivity of capital and result in econmies in investment. It can also save on raw materials by eliminating waste, or turning what was waste, into a usable product. Often, new technology can help set up the manufacture of wholly new products not being produced in the country. In all such cases, the impact of technology on employment is a beneficial one. Even labour-saving devices can result in more employment, if, as a result, output goes up at a much higher rate than the rate of decling in the number of people employed per unit of output. Printing employs far fewer people per sheet of written matter than typing. But, if we stopped printing, employment would go down-not up-because, the whole newspaper industry and publishing industry would virtually have to close down.

Having said all this, I would reiterate that selectivity must be exercised in regard to the technology which we import. There can be situations in which the import of a particular technology would not be in conformity with our priorities, or result in unemployment, or inihibit the use of indigenous technology, because the imported technology may bring with it a fancy brand name, which has a consumer appeal based on intensive advertising but has no intrinsic superiority over indigenous technology. By all means, let us scrutinise cases of import with care, but we must also do so with speed.

I should like to leave the discussion on import of technology with the following quotation from the address by Prime Minister, Smt. Indira Gandhi, to the 69th Annual Session of the Indian Science Congress :-

"Jawaharlal Nehru recognised long ago that political freedom would be incomplete without economic independence, and that economic independence would be beyond our grasp without scientific self-reliance. National laboratories and central institutes were established because national problems needed home-grown answers. This does not obviate the desirability of acquiring, adopting, and absorbing knowledge through technology transfer. We could not have attained self-sufficiency in food had we not imported foreign strains of wheat and rice and fully Indianised them. Similarly, in industry, we now have considerable indigenous fabricating and designing capacity. Having reached a stage of self-reliance, we can and should avail ourselves of more advanced foreign technology without jeopardising self-reliance.

At this point of time, it is necessary for government departments and industries to evolve improved procedures and to identify and notify the tecnologies they require. Obviously, every effort should be made to use indigenous skills and capacities. But, self-reliance should not mean inordinate delays and consequent cost escalation, or the refusal to innovate. Existing methods must be changed if they are no longer serving their purpose of ensuring the timely delivery of equipment and materials which conform to the most rigerous specifications."

The central issue which we have to face is how to maximise the contribution of the scientific talent which we undoubtedly have to the development of our ecnomy. How can scientific research begin to produce the technology we need and how to ensure that the technology we evolve is used to the best advantage.

While in the early phases of development, the technological input was a matter of chance, presently a high proportion of the new technologies are evolved through purposeful research directed to achieve particular objectives. It is in the industrial laboratories and not in the academic laboratories of the universities that the major break-throughs are made. The multi-national corporations have in the last few decades grown bigger and bigger as a result of the research they have financed. The power they wield is such that often the poorer countries, whose national income is much less than of some of the multi-nationals, hesitate to have truck with them. But the technologies they possess are so vital that it is not easy to do without their collaboration in one form or another-except at the cost of slowing down progress. In order that we may get an equally good dividend from our own research, it is worthwhile examining what the secret of the multi-national's success in technology is.

In essence, all research is something of a gamble. Much money can be spent without getting any worthwhile results. As happens in any game of change, such as a lottery those who have a large number of tickets have a greater probability of winning a prize. But by the same token if it happens, and well it may, that none of the tickets draws a prize or the prize is less than the total outlay on tickets, the net result is a loss. In a race if you back all the horses, you can be sure that one of them will be the winner. But the odds being what they are, a policy of drawing a winner in each race by backing all the horses can prove to be ruinous. But if having drawn a winner, you can also decide what the prize money should be. the investment would be worthwhile.

When a multi-national embarks on research, it takes good care to see that the field selected is one which would pay a rich dividend if the effort is successful. In order that others may not use the process on which much money has

been spent, both patent protection and secrecy are relied upon to get into a monopolistic position. A large multinational can afford to make very substantial outlays on research of this nature with the confidence that if it succeeds in even one of its efforts, it can get a bonanza after taking care of all the expenses. Since the bigger the organisation the more its resources, there is a snowballing effect of success breeding upon success.

A few decades ago, there was not quite the same kind of a growth cycle. Some small business houses were lucky with their experimentations which sparked off a cumulative process of growth. Zeroz was but a small paper merchant as late as in 1950, I.B.M. in the office equipment industry was but a small company even during World War II. Many of the pharmaceutical giants of today were either small companies or had just come into existence at the end of World War II. Such success stories are there. But today they are the exception rather than the rule.

Giant Corporations make massive outlays on research which is specifically-oriented to achieve a break—through in areas where success would be highly rewarding in terms of profits. In carrying out such in—house research there is the closest possible link between those evolving the new technology and its users. There is constant feed—back of information. A process evolved in the laboratory can be readily tested on a larger scale in the factory. What ultimately emerges is not a process which will need to be adapted but something which is ready for use and application.

Finally there is the assurance that those who finance the research will, if it is successful, provide the money to apply it to production, while research workers in independent laboratories when they discover something which would lead to technological advance, have to try to sell their process to some user or other, the fruits of R & D are immediately picked up by those who finance the research

The three essential features which account for the phenomenal success of multi—nationals in the technological field are purposefullness, link between the research workers and the users of technology and availability of finance to put the successful research to productive use. That these are the three main ingredients of a successful technology policy is borne out by our own experience in India.

If we look at the success, the transformation of wheat production by the injection of new technology as well as the strides which we have made in nuclear technology and space technology would stand out as major achievements. In each of these fields the three criteria of success were fulfilled. Firstly, research was directed towards overcoming the problem of the producers who needed the technology. The adopton of Mexican high-yielding variety of wheat to Indian soil and climatic conditions was conducted with the full knowledge of the difficulties and problems of the farmer. Research in nuclear and space technology concentrated on overcoming the felt problems and removing the obstacles in the way of those who would use the technology. Secondly, links between research worker and users of technology were close and intimate in the nuclear and space field and were provided by extension service in the agricultural sector. And thirdly, it was never in doubt that money would be available to put the technology to immediate use.

On the other hand, the areas of frustration are those where research has been conducted without any real guidance or direction according to a well conceived plan of priorities. Often the effort is to find an indigenous alternative to a technology already available outside. Such research often proves to be frustrating. The time taken in developing an alternative can be quite long. It may not be too easy or even desirable to wait hopefully for the success of the research while the economy may

need the process as a matter of urgency. We lost much additional production which we could have got without any new investment in the cement industry because the import of pre-calcination technology was held up for two years in the belief that it would become available from the on-going research. But the hope was never fulfilled.

Many cases of success in the laboratory cannot be translated into use, firstly because it is difficult to locate the users and secondly because of the unbridged gap between success in a laboratory and all that is needed to apply it to industry. This is primarily on account of the absence of continuing inter-action between research and industry. Finally, the potential user even if he is located, may face financial difficulties in adopting the new process or he may run into administrative hurdles in making use of the process. A most significant technological break-through we have had recently has been a process to make sponge iron with non-coking coal. No other country except South Africa has it. I gather, its exploitation has been delayed because clearances take so much time.

Against this background I suggest we must evolve a positive programme for making fuller use of our technological capabilities to assist our development. The first thing we must do is to ensure that the quest for new technologies has clearly defined objectives. While pure scientific research must be free and the scientist should choose for himself the area which he would explore, the pursuit of technological advance has to be guided by clearly defined objectives. It is not for me to suggest what these should be, but I do want to put forward some thoughts in regard to the criteria on which the choice should be made.

Firstly, our emphasis should be on problems which have a high importance for us but not for the developed count-

ries, where most of the research is being carried on today. Thus in the drugs field, while most of the research in developed countries is in ailments afflicting the over-nourished, for us the priority has to be for diseases of the under-nourished. Our medical research could well focus on diseases which are endemic here.

Indeed, one of my objections to import substitution as a guiding principle for technology research is that it would distort our priorities and divert our scarce resources into the wrong channels. I have said earlier that the multi-nationals only select fields which would yield the highest profit. Now, it does happen that something which may be very profitable commercially may also be most beneficial socially. If a drug is found which can help combat fatal diseases like cancer, not only those who discover it but the human race as a whole will gain much. But much of the research by the multi-nationals is for purposes which have little relevance in our conditions. In selecting fields of research in India we should not ignore the profit potential which all economic activities must take into account; but social benefits must be given equal weight. For example, I do feel, it would be a waste of our resources if we try to evolve a technology of our own for making colour television sets. We should certainly undertake research in the same areas as other countries, provided the problem has an urgency or priority for us also. Family planning is one such example, where for all the research which is being done in other countries, we should press ahead with our own efforts.

A second factor influencing our priorities would be the knowledge that the technology we need is likely to be denied to us even if it is available in other countries. This consideration applies not only to defence industries but also in the nuclear area, as is well known. What is not so widely appreciated is that developed countries and the multi-nationals, who own much of the latest technology, are

reluctant to see a transfer of such technology to developing countries as would make their economies self-reliant. The question of transfer of technology is one of the most hotly debated issues in the North-South context. At one time, developed countries were propagating the theory that what the third world needs is intermediate technology-of the kind which the western world used before World War I. The argument was put forward on the consideration that the latest technology is capital intensive while the earlier technology was more labour-intensive which would suit developing countries with their massive unemployment problem.

Now there is a case for going in for labour-intensive industries in countries like ours, but there is a whole range of industrial development which we cannot afford to ignore which is by its nature capital intensive. Fertilisers, petrochemicals, machine tools, the basic drugs, all need heavy capital investment. To the extent that we go in for them, we must have the latest technology. Let me also add that it is simply not true to assume that all technological advance raises the capital intensity of the product. Raising the productivity of capital and thereby deploying fewer units of capital for each unit of output is also an objective which technology serves and which we need badly.

Once a purposeful choice of the areas of research has been made, links should be established between the scientists working on the problem and their potential users. The mere discovery of a process is not enough. A successful experiment on a laboratory scale may take years to become usable in the factories. It took over 20 years between Siemens' design of the first electric dynamo to Edison's electric light bulb, which made possible on electrical industry. The lead time for the conversion of new knowledge into effective technology can be shortened considerably by developing closer links between the producers and consumers of technology.

One reason why Indian industry seems reluctant to make use of indigenous technology and has a preference for imported technology is that the latter offers something much more than a process. There is also the offer of equipment to make use of the process and knowhow to make use of the equipment. Interaction with the potential users of technology as well as the involvement of those who might, in appropriate cases, supply the equipment for the use of the process, can greatly facilitate the objective in view. One of the ways in which this can be done is by industrial units having their own research establishments. Our tax laws do encourage R & D expenditure but for a variety of reasons only a relatively few enterprises seriously go in for research. Much more research is being done in State-owned laboratories, but because they work in isolation their efforts are not easy to translate into practical application. The multidisciplinary character of research needs to be recognised and the appropriate organisational arrangements made for the transmission of technology from the laboratory to the factory.

One of the known reasons why Indian industry is not more actively engaged tn the development and use of indigenous technology is that in the absence of competitive conditions, producers have no motivation for making experiments and introducing innovations. Our passenger cars illustrate the point. As a rule, demand for them has always outstripped the supply. Commercial imports are banned. In consequence, manufacturers have not been much interested in improving their technology even by importing it much less by sponsoring domestic research. Among the steps which I would urge to interest our industry in technical innovation is to offer them some inducements appropriate to our conditions. The Government can make it a clear policy that to the extent higher production of new products can be attributed to indigenous technology, neither industrial licensing nor the MRTP regulations nor FERA regulations will

come in the way of the new techniques being fully exploited. A stimulus of the right kind could thus be provided to indigenous technological progress.

When thinking of links between research and industry, we should not, as is common, confine our attention to larger industries alone The small scale sector and our handicraft industries are often relying on inefficient and traditional methods with the result that in order to survive they need protection from the competition offered by large scale industry using more advanced technology. Such protection is justified because of employment considerations as well as from the angle of regional development What gets overlooked in this laudable effort is that if we can simultaneously take steps to improve their technology so that while retaining the employment potential in full, quality can be improved and costs cut down, then these industries can stand on their own feet and forge ahead. It is a pity that some of the champions of village industries have an antipathy to departing from traditional ways and tools. I cannot help recalling in this context that Mahatma Gandhi was most anxious to see such improvements in the charkha as would enable the spinner to produce more and earn more.

Another area in which special efforts can be made to improve the technology is to be found in our export trade. There was a time when we exported only primary products or semi-processed goods, raw cotton and grey fabrics, iron ore and pig iron. We have in more recent years started exporting garments as well as engineering products. The move is in the right direction for more reasons than one. We get more value and more employment, as the extent of processing in India is carried farther and farther. There is also the consideration that there are serious limits to the extent to which we can step up the volume of exports of our primary products. As our population increases and as

our standard of living and consumption goes up, our exportable surpluses dwindle. In many instances, such as vegetable oils of which we were powerful exporters at one time, we have now become major importers. Sugar is somewhat similarly poised. We can never get out of the foreign exchange trade unless the technological content of our exports is steadily increased. Instead of exporting technologists, as we do, we should be exporters of technology, particularly by raising the technological content in all that we export.

Towards this end, we should allow export industries to make free use of all the technology that may be available in the world, provided that thereafter they really try to rely solely on their competitive strength and not on incentives to sell their products. Once they embark on such a path, they will be compelled to seek to get an edge over their competitors, by improving upon the imported technology, as Japan did. Their task will be the easier because we have the manpower and the talent which could be harnessed for the purpose. One of the things which saddens me is that in many products the most intense competition which we face is from exports made by other developing countries whch are able to market products which are technologically superior to ours—despite the fact that in terms of technological capability we are far better than they are. The attempt so far has been to meet this competition by some form of subsidisation which means a national loss. Instead we should improve the technology and give every facility for that purpose.

One of the areas in which we could have a vast export market is to be found in what is known as software for that computers. We have the manpower for it available at much cheaper cost than anywhere else in the world. But no organised effort has been made to develop the export of software from India in a big way. Some countries which

offer the necessary facilities and encouragement are using Indian scientists for developing the export in software.

Finally, at the time when a choice is being made to the purposes to which research would be directed, there should be a commitment to provide the necessary investment to make use of the products of sucessful research. While for the private sector industries, reliance for the purpose will have to be placed on indirect inducement, for the public sector the investment commitment has to be made as a part of the Plan. Since our Plans are dedicated to development, in order to ensure the maximum contribution of technology to development, the Plan should not merely provide funds for research, it should identify the targets and make a contingency provision of funds to exploit the success in our research effort.

An integral part of the composite effort to stimulate the development of technology must be an attempt to reward those who help to create new technology. There are some concessions in our tax laws to promote expenditure on R & D. It has been said that they are open to abuse : to take advantage of the concession the expenditure is incurred regardless of result. There are also some tax incentives relating to technology transfer whose accent is more on the foreign exchange angle than on promoting research. What is worse, in our indirect tax system, there seems to be a built-in bias to have higher levies on all products which make use of new technology, in the belief that they are necessarily luxury goods. All too often, the taxes imposed on this consideration have the effect of ensuring that only the rich can buy such products, the poor do not benefit from technological advance.

The slant in our indirect tax system to encourage more employment and discourage labour saving devices is justified. But this should not lead to an anti-technology bias.

We must rather ask which technology is beneficial to the poor, not merely from the employment angle but in terms of satisfying their needs and improving their living conditions. Tax laws should encourage their use, and thus promote the development of technology which will really benefit the poor.

When thinking of rewards for fruitful research, we should think not just of tax concessions to corporations. We must think much more of the research workers. I am not at all sure that putting them into service cadres, with pay scales on a par with those of administrators, is the best way of promoting technological advance. It often, I suspect, has the effect of introducing the bureaucratic culture in the scientific arena, emphasizing the role of seniority as a yardstics for promotion. A system of cash awards for research which is economically beneficial, may be a step in the right direction.

But even more than the financial incentives need to create conditions in which scientists feel that their work is appreciated. Their living and working conditions need to be improved. One of the factors which has contributed significantly to India's success in atomic research and space research, was the sense of involvement and dedication which were created in the research workers by those at the head of the concerned institutions , particularly Dr. Homi Bhabha and Dr. Vikram Sarabhai.