# THE THREE TECHNOLOGIES

RODDAM NARASIMHA

Department of Aerospace Engineering, Inaian Institute of Science, Bangalore 560 012, India

## ABSTRACT

The technology scene in India is at one and the same time promising, frustrating and fascinating. Three broad areas in technology development can be distinguished. The first is relatively small scale; it is typified by the absorption of products of the industrial revolution into the repertoire of the Indian artisan and craftsman, examples being diesel engines from Kolhapur and centrifugal pumps from Coimbatore. The second class is essentially 'state technology', developed at public expense by national commissions: agriculture, atomic energy and space are examples. There is a vast third area in both private and public sector, covering products for the urban consumer and the state (*e.g.* defence); this area has largely remained colonial. The factors affecting the three areas of technology are described and analysed from the point of view of an Indian scientist-engineer; and it is concluded that the enormous potential of the country's human and material resources is not only unrealized, but even unrecognized as yet.

THE development of indigenous technology in India, which has been a declared national goal for many years, presents some intriguing patterns. On the one hand, the country is now among the ten largest industrial powers in the world; it has the third largest technical manpower force; it is a member of a small exclusive club of less than ten that can design and build their own nuclear reactors, satellite launch vehicles etc.; it is one of the very few countries in the world that produce enough food for themselves. On the other hand, many of the products of Indian technology are of poor quality, or are obsolete copies of thirty-year old (or even older) designs; we donate a large number of trained scientists and engineers abroad, and so subsidise the West by far more than the 'aid' they have given us, but, at the same time, we cannot employ all the trained manpower we do retain; there is a large section of the population that is still not fed properly; and-to pick one example-the aeronautical equipment we buy (for what is perhaps the fifth largest Air Force in the world) helps substantially to keep R&D going in British and French industry. We designed and built an indigenous aircraft twenty five years ago; we still have not evolved an indigenous bicycle, let alone an automobile. In fact the technology scene in the India of 1980 reminds one of what Charles Dickens wrote on the Europe of 1775: "It was the best of times, it was the worst of times...it was the season of Light, it was the season of Darkness ...it was the spring of hope, it was the winter of despair...", etc.

In analysing this paradoxical situation, it becomes clear that, like everything else in India, the technology scene is also full of a diversity that will appear bizarre to any detached observer. To understand this diversity it is necessary to distinguish between at least three different classes of new technology in India (there would be many subclasses under each of these categories).

The first may be called 'backyard' technology for lack of a better term. This is characterized by an absorption into the traditional Indian system of some widely-used product of the industrial revolution; during this process of absorption methods of manufacture have been evolved that suit the resources-material and human-available in the country. In some cases design changes may have been made as well. But these adaptations have not come as a result of conscious R&D, but of evolution from experience in the field and in response to the pressures of the market place. Examples abound: centrifugal pumps from Coimbatore, machine tools from Jullunder, diesel engines from Kolhapur (-India is the largest producer of small diesel engines in the world) etc. These products are not advertised in the national press, and do not circulate in the national market; but they are well known to a local clientele which, by experience and word-of-mouth, is able to make reliable assessments of the qualitites of the product.

These 'backyard' industries are not always necessarily small and some of them are getting to be quite sophisticated. But I think it is fair to say that this class of technology is founded on the native ingenuity of the people, and represents the absorption of products of the industrial revolution into the repertoire of the Indian artisan and craftsman; the Kolhapuri diesel engine may well become a product with its own distinguishing character, appeal and identity, just as much as Kolhapuri sandals are now.

The second class is what may be called 'state technology'; this is typified by developments in such fields as atomic energy, space, agriculture*, etc. Here the initial 'designs' may have been inspired by foreign examples, but their adaptation has involved a serious R&D effort which has resulted in a mastery of all significant aspects of the technology adopted. In these cases, both the know-how and the know-why have been generated; both the science and the art have been absorbed. The contribution of these efforts to the 'strength' of the nation, defined in a broad sense, cannot be over-estimated. Their contribution to the economy is obvious in agriculture, but in other fields is not always easy to assess at the present time. But perhaps the most important point these achievements have made is that, in spite of the much-advertised defects of our bureaucracy, educational institutions and R&D organizations, sufficient resources and talents are available in the country to master any technology that is considered of such national importent that it is backed by political will and financial support. The formulation of clear goals, the absence of large foreign commercial interests and the pressure of geopolitical considerations appear to be key factors in the success of Indian technology in these areas. Appendix A shows the magnitude of the R&D effort that the country has undertaken in some of these areas. The self-sufficiency in food that we now enjoy has cost the country something like Rs. $1\text{–}2 \times 10^{11}$ (Table A3) - a sum that will generally be agreed to have been well worth the result, considering that around the time of the Bihar famine of 1966–67 many Westerners were ready to write off India for ever.

* The word 'technology', as used in this paper, denotes the pool of skills available in a society for the control of the physical environment in which its members live; in this sense, which appears the only reasonable one for present purposes, both agriculture and medicine are part of 'technology'.

## APPENDIX A

TABLE A1

*Central Government S&T budgets of major organizations 1979–80*

| | Rs/cr |
|---|---|
| Atomic energy | 68.6 |
| Space | 74.1 |
| Science and Technology | 55.9 |
| CSIR | 51.2 |
| Defence R&D | 69.4 |
| ICMR | 8.0 |
| ICAR | 87.8 |
| Electronics | 9.2 |
| Total | 424.2 |

TABLE A2

*Expenditure on R&D*

| | Rs/cr | % |
|---|---|---|
| Central Government | 558 | 81 |
| State Government | 56 | 8 |
| Private Sector | 75 | 11 |
| | 689 | 100 |

TABLE A3

*Outlays on Agricultural and rural programmes*

| | Revised plan, 1974-79 | Draft 6th plan | Annual plan, 1979-80 |
|---|---|---|---|
| | Rs/cr | Rs/cr | Rs/cr |
| Agriculture and related sectors° | 4644 | 10538 | 1815 |
| Irrigation and flood control | 3434 | 7604 | 1260 |
| Total | 8078 | 18142 | 3075 |

° Includes: minor irrigation, soil conservation, area development, food, animal husbandry and dairying, fisheries, forests, agricultural and financial institutions community development, and cooperation.

It is clear (Table A2) that the major promoter of such new technology is the Central Government, which accounts for more than 80% of all expenditure on R&D in the country.

These two classes of technology-'backyard' and 'state'-show what enormous potential the country has. The third class, on the other hand, shows how this potential is still largely unutilized in the biggest sectors of our industry: namely those that supply industrial products to the urban consumer-a term we use to include not only individuals but organizations as well, such as private and public sector industries manufacturing a variety of products, from transformers to telephones to aircraft. These products are by and large made according to designs bought from elsewhere; and the 'licencee' makes no effort at adaptation or innovation, and indeed shows an extraordinary reluctance to undertake even the smallest modifications without the 'approval' of the concerned 'principals'. (To nobody's surprise, such approval is rarely forthcoming!) Many examples can be quoted: our automobiles are probably the most familiar, but aircraft, electrical equipment and numerous other products exhibit the same total and pathetic dependence on some foreign 'licence' These industries seem basically incapable of taking calculated technological risks (or are unwilling to do so); they have not developed techniques by which such risks can be assessed and gradually eliminated. Perhaps these industries have not found the need to do so; in which case national economic policy would seem to need revision.

I would like to discuss the aircraft industry in particular, because of my own familiarity with it. This industry, especially in India, cannot be separated from defence, because what industry we have is run by the Ministry of Defence Production, presumably for defence. (This is not unreasonable: manufacture of civilian aircraft need not be ruled out, but while the internal market for civilian aircraft is clearly limited at present, and the external market is so fiercely competitive that it is hard to penetrate, the market for military aircraft for the world's fifth largest Air Force surely cannot be insignificant.) Appendix B provides some statistical data on outlays in India on defence, defence R&D and defence industry. It is clear that the expenditure on defence R&D is small no matter how one looks at it: relative to our defence budget, or to the cost of the military aircraft we import, or to the output of defence industry, or to R&D in the same area in other countries. And this conclusion applies with even greater force to aeronautics, which forms only a part of the defence effort.

The aircraft industry in India traces its origin to the Second World War, when it was set up to service the allied Air Forces. Soon ater the War design activity started, and during the fifties three projects were on hand, leading eventually to the production of such indigenous aircraft as the HT2 (a piston-engined basic aircraft), the HJT-16 (a jet trainer) and the HF 24 (a combat aircraft). The R&D effort in aeronautics was at that time almost non-existent, but the plans and projects then formulated were informed by a vision and daring that have since been conspicuously absent—ater 1960 not a single new project of comparable scope has seen the light of the day, although numerous design studies on paper have

* With the ambiguous exception of the HF 24, whose design was led by a small team of German engineers in India; this aircraft is now being phased out.

been made. What is particularly strange is that recent decades have also seen a marked growth in R&D laboratories: most of the technologies required for the design and manufacture of combat aircraft are now being explored and mastered in some laboratory or other.

APPENDIX B

TABLE B1

*Defence R&D*

| | |
|---|---|
| Total defence R&D expenditure 1962–73 | Rs. 152.5 cr |
| DRDO budget, 1979–80 | Rs. 69.44 cr |
| Total defence expenditure 1979–80 | Rs. 3050 cr |
| Defence/total government expenditure | 21% |
| Defence/g.n.p. | 3½% |
| R&D/total defence expenditure | 2.27% |

*Percentage (R&D/total defence) in other countries (approx.)*

| | |
|---|---|
| USA | 8 |
| UK | 11 |
| China | 20 |
| France | 15 |

TABLE B2

*Defence undertakings in the public sector*

| | | |
|---|---|---|
| No. of undertakings | | 9 |
| No. of employees | | 95,000 |
| Production | 1977–78 | Rs. 417.5 cr |
| | 1978–79 | Rs. 427.0 cr |
| Total investment | 1978 | Rs. 258.0 cr |
| No. of ordnance and equipment factories | | 32 |
| No. of employees | | 1,50,000 |
| Gross value of production | | Rs. 465.0 cr |
| Investment | 1975–76 | Rs. 351.0 cr |
| HAL production | 1973–74 | Rs. 98.0 cr |
| Unit cost of Jaguar° | 1981 | Rs. 10.0 cr |
| Unit cost of Mirage 2000° | | Rs. 20 cr |
| Cost of 100 Jaguars° | | Rs. 1000.0 cr |
| Life cycle cost of 100 Jaguars° | | Rs. 4000.0 cr |

°Approximate figures.

Looking back, the decisions taken in the 1950s by Jawaharlal Nehru and his government appear now extraordinarily bold; in the two decades since then, in contrast, the country seems paralysed into inaction. Much debate has gone on about why this has been so, and many explanations have been offered. But there can be no doubt, in the light of our previous discussion, that the potential of the country is not being utilised; as Table B2 shows, the cost of development of a new aircraft (of the order of several hundred crores) would be a small fraction of the cost of acquisition of new aircraft for the Air Force, or of the kind of outlay the country has made in areas that were considered crucial.

It should be emphasized that the point I am making is *NOT* that our defence expenditure be increased, nor even that defence R&D must get more: such increases, if not backed by more determined policies and clear philosophical and technological goals, would probably do more harm than good. The point rather is that whatever out total defence expenditure is, the country should gain if more of it is spent at home rather than abroad. It is remarkable that India has the largest Air Force in the world that does not fight with its own (indigenous) designs*.

Other large-scale consumer industries suffer from the same weaknesses, although they may be financially successfull; basically, all these industries are still 'colonial'. I wish to suggest that the problem here has been (to place the best interpretation on the facts) a lack of will or a lack of confidence.

As Sir Arthur Lewis, the Nobel Prize winning economist, has shown, the engine of growth is technological change. Very few people with money in India have realized yet that the country is sitting on a gold mine, and (given the imagination) is now all set to emerge as a major industrial power in the world. Clearly, we do not lack either material or human resources; the problem therefore must be one of psychology, and of management—psychology in the sense that we suffer from what may be called the 'desi mal' complex ( = 'craze for phoren'); management, in that a constant search for major structural changes and radical transformations, in pursuit of some foreign ideal, prevents us from articulating, how vast improvements can be effected working within the developing 'Indian' system (which now has a sufficient number of successful models). The extraordinary philosophical changes occurring in post-Mao China indicate that the broad policy that India has followed in economic development—although it may seem muddled and has found no eloquent advocate yet—is not fundamentally unsound. It is only necessary now to invert the question, and ask ourselves how we can use our imagination to manage our vast human and material resources at all levels—on the shop floor, in the board or committee room, and along the corridors of power—for the prosperity and strength of the nation.

This paper is based on a lecture delivered at the Regional Centre for Technology Transfer, Bangalore on 6 February 1982 at the invitation of its Director Dr. C. V. S. Ratnam. The thoughts expressed here congealed following some interesting discussions with Mr. S. V. Sastry on diesel engines, and with Prof. M. N. Sreenivasan and Prof. M. V. Narasimhan on the automobile industry. I sincerely thank all these gentlemen. The tables have been compiled from the references cited below.

1. India 1980. Government of India.
2. Agarwal, R. K., Defence production and deveopment. Arnold-Heinemann, New Delhi, 1978.

# ANNOUNCEMENT

## INDIAN ACADEMY OF SCIENCES, BANGALORE

The Forty Eighth Annual Meeting of the Academy will be held at Nainital from 9 to 11 October, 1982.

The Meeting will start with the Inaugural function and Welcome address by Dr. S. N. Srivastava, Vice-Chancellor, University of Kumaun, followed by Introduction of Fellows by the President. The Presidential address by S. Varadarajan, Secretary, Department of Science and Technology, New Delhi, will be 'New World of Plymers'.

The Lecture presentation by Fellows on the First Day will be by Dr. T. C. Anand Kumar on 'Ethical considerations in Animal Experimentation'; Dr. M.N. Rao on 'Origin of our Solar System: Early events, time scales and their consequences'. The Symposium on 'Ecology of the Himalaya Mountain' will be followed by presentation of papers: Dr. T. N. Khoshoo on 'Himalayan Plants—alternative source of energy and food'; Dr. S. L. Shah on 'Biotic pressure and economic versus ecological security in the Himalayan region'; Dr. J. S. Singh on 'Forest ecosystems of Kumaun Himalaya'; Dr. M. A. Rau on 'A look at the flora of High Himalaya; Dr. B. P. Ghildiyal on 'Degradation and conservation of soil in the central sector of the Himalayas'; Dr. K.S. Valdiya on 'Seismicity and erosion in the Himalayas'; and Dr. R. C. Misra on 'Environmental problems created by exploitation of mineral resources in the Himalayas.'

The lecture presentation by Fellows on the Second Day will be as follows: 'Functions of cyclic 3', 5'-adenosine monophosphate and receptor protein complex in *Escherichis coli*' by Sushil Kumar; 'The scope for novel synthetic chemistry in drug research' by S. Rajappa; 'Electronic structure of iron in synthetic Beam systems' by S. Mitra.

The Second Day Symposium on 'Polymer Science and Engineering' will be consist of the following lectures 'Whither Polymer Engineering?' by R.A. Mashelkar; 'Recent Advances in Polymerization of Ethylene and Propylene' by S. Sivaraman; 'Polymer Alloys: Science and Practice' by Vikas Nadkarni; 'Simulation and Optimization of PET Reactors' by S. K. Gupta; 'Recent Developments in the Chemical processing of Textiles' by M. L. Gulrajani.

The Lecture presentation by Fellows will be as follows: 'Light fluctuations and their applications' by C.L. Mehta; 'From Liquid to solid' by T.V. Ramakrishnan; 'Phase transformations and structure property correlations in zirconium alloys' by B.A. Dasannacharya.

There will be evening lectures on the First and the Second Days.

Further information may be had from the Secretary, Indian Academy of Sciences, Bangalore-560 080.