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Special Issue

Editorial

The Prime Minister's Science Round Table

The most significant aspect of the Science Round Table has been the timing of it. It was a welcome idea of the Prime Minister to invite a group of scientists mostly from the younger and middle age groups to meet without any formal agenda and let go their thinking on the general science situation, as also somewhat more specifically about the scientific temper, organisation of science and planning and utilisation of scientific research and technology. Not much is to be expected of such meetings which are essentially in the nature of a get-together and there need be no disappointment that the Round Table did not produce any earth shaking recommendations. Criticism in some quarters of why and who were invited is hardly meaningful because the Round Table could not have done better even if others had participated. A reading of the panel reports would reveal that nothing new emerged. There has been a restatement of the well-known problems and their remedies, which are all too familiar. Still we hope this effort would not be a waste and this Round Table may mark a change in attitude to science at the national level. As a participant said, "what we need is not more policy documents but implementation of what has been repeatedly discussed and decided."

There was a frank admission that almost nothing had been done by way of implementation of the Science Policy Resolution adopted nine years back. An equally outspoken statement was that although numerous science institutions have come up and there has been a horizontal growth in scientific effort, there is hardly any machinery for science planning, co-ordination or relating scientific and technological effort to national needs. Some thinking has been done by the Round Table as to how the situation could be corrected. A tentative approach for an organisational set up to determine the priorities, allocate resources and a budget for science has been indicated. The Round Table considered that the Scientific Advisory Committee to the Cabinet should stay as a useful tool for advisory function but suggested its activation through induction of a full time Chairman and a small permanent staff of science analysts. (Some of us feel that shedding of old dead-wood is equally necessary!) The thinking of the Round Table, however, does not appear to have gone beyond consideration of science in terms of scientific disciplines. It is well recognised that science planning, science policy and science of science have become a field by themselves and are not necessarily 'discipline oriented'. The Round Table has sponsored the idea of the setting up of National Council for Science & Technology which should perform the overall function of coordination and planning of scientific research effort at a national level. Understandably, consideration in depth has been avoided. There is a reference to the Ministry of Science and Technology though if it is to perform only the functions as stated, there should hardly be justification for creating a new Ministry. If it is to be effective it should have the related executive functions of implementation of science policy and being directly involved in enforcing decisions arrived at by the National Council for Science & Technology. The Round Table unanimously advocated the setting up of a National Academy of Science & Technology to function as a single national society with a special and specific charter on the lines of the National Academy of Sciences of the United States. One would however doubt the advisability of creating this through the merger of the four existing professional societies. This may mean collectivisation of the handicaps from which these bodies are known to suffer. A useful approach would be to lay down the criteria of membership and start with a clean slate so that the proposed National Academy has some chance of a healthy parentage and fruitful existence. The role of this Academy should be purely advisory and it should derive its authority and prestige from the scientific eminence, integrity and wisdom of its members. It should have the academic freedom to deliberate and pronounce upon any matter of scientific importance, but should be kept clear of any involvement in governmental work or executive tasks.

It is no secret that during the last three years the pivotal role that science and technology should play in national affairs has been receding. While the Science Policy Resolution promises a place of honour to science and scientists, both have now been relegated to a back seat. Considerations other than scientific viz. communal and sectional have come to the forefront and plagued the policies of the country at high levels. Public have become victim to fissiparous, sectarian and other negative tendencies which have tended to divert time and effort from tasks of national reconstruction. While on the one hand the position has led to retarding of economic growth, on the other it has created a psychology of lack of faith and confidence in science and technology and even in the destiny of the country. Both at social and economic levels, such a psychological situation is fraught with disastrous consequences. An immediate reversal of this unhealthy trend is called for and it is in this context that we consider the calling of the Round Table by the Prime Minister of significance. It symbolises the renewed interest of the highest authority in the Government in the affairs of science and technology.

The obvious neglect and secondary position to which science and technology have been driven as a department of the Ministry of Education, have done great damage to their prestige, role and usefulness. The situation can only be remedied if the Prime Minister takes upon herself the portfolio of science and technology. One would like to avoid adding to the burden of the Prime Minister whose guidance is necessary in the overall affairs of the country, but unless the highest place is immediately accorded to science and technology, this would cease to be the major factor it ought to be in national life. We firmly believe that salvation of the country lies in directing the outlook and energies of the people to constructive tasks and towards this end laying increasing emphasis on the maximum and dynamic application of science to the affairs of the country. This would only be possible in the present circumstances if the stewardship of the Ministry of Science & Technology is considered as of a key portfolio and worthy of Prime Minister's personal direction. The other aspect to which we attach the highest importance is the implementation, without any delay, of the recommendations

(*Contd. on page 4*)

Scientists as Artists : What shape Science ?

K.T. Achaya*

Overture

On September 7 and 8, 1967, fifty scientists and technologists called together by the Prime Minister, assembled at Vigyan Bhavan for discussions on Indian science and administration, which were to be 'informal and intended to promote a frank exchange of views with its object of identifying problems and their possible solutions rather than taking decisions'. Very few of those invited failed to turn up, and some carried brief cases of alarming dimensions. The majority in the gathering fell into a lower middle-age spread, and it was these who later plunged into verbal scrimmage. The occasional greybeard, or more accurately shiny pate or peak cap, preferred to keep his counsel. The participants were drawn from the CSIR, AEC and TIFR, the rest being spread thinly over Defence, Agriculture, Medicine, the Universities, Railways, private industry and the Planning Commission.

The Prime Minister spoke simply and earnestly of the 'third culture' of superstition, dogma or simply inertia, and of science being as much an attitude as a physical accomplishment. One hoped that the scientists were taking mental stock of themselves. The science policy resolution, excellent as it was, had lain fallow, a pious hope. She quoted a visitor to India as having shown special concern for the low targets for scientific education. And higher up chasms were growing — between science and administration, between science and industry, and between science and planning — while time horizons and expenditure ceilings grew ever more finite and brief. Shri D.R. Gadgil of the Planning Commission went on to relate planning to science and technology; purposeless one without the other. How, he asked, could breakthroughs come in industry or agriculture except through their agency, and then again how, except when indigenous ? Visions of the good future beckoned fleetingly. Others who followed gave promise of new winds of thought blowing through the corridors of planning. Shri C. Subramaniam was present, but listened.

The scientists now spoke for themselves, or so it sometimes seemed, to hear them-

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selves. To one, youth was all very well in a laboratory but at a conference table age alone brought the highest wisdom. If past figures were any guide to priorities, both mechanical engineering and agriculture should, like Abou-Ben-Ahdem, lead all the rest. Beguiled by the shining horizon of plenty through big technology, the country had jumped too eagerly on the industrial bandwagon, and University research, fecund mother of all the rest, had received less than step-motherly attention.

Modus operandi

After lunch, to work. Divided now into three groups of their own choice, and the large horse-shoe of scientists had yielded to smaller round tables. Chairmen were soon found to keep things on rails. In the first panel, which the writers sat with, the attempt was to shed a little new light in vexed areas on which thousands of words have already been lavished in press and ministerial pulpit : questions like science popularisation, the business of language, the brain drain. The pattern of discussion often consisted of casting a provocative poser, which was hotly contested, and the area of disagreement narrowed down into an area of agreement with some loud thinking. We were at it for two sessions of six hours in all, and the Chairmen spent a good part of the lunch hour, at which a relaxed Prime Minister joined us, in preparing statements which were meant for presentation to the total assembly on the afternoon of the second day.

(*Contd. from page 2*)

of the Round Table on the creation of necessary machinery for coordination and planning of scientific effort at the national level. The former Planning Commission failed pitiably in its task in planning science in depth or relating scientific effort to the goals of national development. No time should be lost in setting up a National Council of Science and Technology under the chairmanship of the member of the Planning Commission in charge of Science and providing the necessary infra-structure for this Council. The Council must be charged with the task of making science and technology a real instrument of industrial and economic development. The Ministry of Science and Technology should ensure that the plans and proposals of National Council of Science & Technology do not remain paper documents and be accountable to the Parliament and the people for putting life in the Science Policy Resolution of 1958. The scientists for whom this was a refreshing experience would unhesitatingly give their best and dedicate themselves to the objectives enshrined in the Science Policy Resolution if the Prime Minister takes the lead and enunciates immediate and dynamic steps in giving a practical shape to the planned approach to science advocated by the Round Table. Too long has the dead hand of an aimless administration hampered and frustrated the efforts of the scientists. It is time to make a fresh approach and give the scientists a chance.

The Prime Minister, Shrimati Indira Gandhi's call for hastening of Scientific Revolution

Text of the Speech by the Prime Minister on the inauguration of Round Table of Scientists & Technologists held in New Delhi on September 7 & 8, 1967

Perhaps you all know that I have begun this series of get-together or round tables as we call them not merely to allow fruitful discussion but also to keep me in personal and firsthand contact with the minds of important sections of our people. I have great pleasure in welcoming you all for an exchange of views on what is obviously a subject of deep concern to us all, that is, Indian science and technology and its utilisation in building a better life for our people and our country.

Science as most people understand means rather complex research and the application of the findings of such experiments. It means probing the secrets of our world and harnessing the power of nature for our own needs. We are apt to forget that at the ground level it means combating superstition and the deadweight of outdated habits and customs. In India we have to contend not with "Two cultures" but with three. The third category in India as in any developing country is, of course, superstition, tradition and similar forces of inertia. The role of science in such societies must be as much to promote, rational inquiry and judgment as to encourage research and development. Science is not an objective but really an attitude and therefore it means the inculcation of new attitudes and a spirit of rational inquiry amongst the people as a whole so that they turn to science and technology to transform our agriculture and our industry.

Jawaharlal Nehru clearly recognised the importance of science. It is due to him that we, as a people, have at least some consciousness of science. He talked always of the scientific temper and went to the smallest village and the remotest parts of our country to educate the masses regarding the role of science in their life. He founded a chain of national laboratories and established what is now the Bhabha Atomic Research Centre in Trombay. It was under his inspiration that Government adopted a Scientific Policy Resolution in 1958. But there we have stopped. This is really my concern and the need I felt for calling such a Round Table because I am getting numerous letters from visitors to our country as well as eminent scientists in other countries who write practically accusing me that nothing has happened for these several years and that we have not progressed further. I would like to share with you the views of one such eminent visitor to our country. Although it is not directly linked with this Round Table, it is something which, I think, is important in creating a scientific temper and in giving a base to science in India. He writes:

"Much of what I saw was wonderfully good; for example, Trombay, the Tata Institute, the All India Institute of Medical

Sciences and several stations and sections of the Council of Scientific and Industrial Research. I will not burden you with praise of these; they are going well on the path that they have taken and need no cheering on from me.

But the same is not true of the overall plight of scientific education in schools and universities. This is a state of affairs which, in my view, will get worse and not better at the present rate of progress. Science occupies a minor place even in distinguished universities and attracts neither the best teachers nor the best students.

The failure of science to take hold in schools and universities and indeed its strangulation by traditional subjects there, can only be reversed by setting much higher targets for scientific education than those now planned. The targets proposed at present are too low and too slow. They cannot push science ahead of the economy and turn it into an industrial leader. Science and all aspects of a truly modern education can only forge ahead in India if farsighted minds accept the thesis that it must be given a disproportionate share of the national cake now. Only so can the national cake itself grow faster in the future. The cost of scientific education must be accepted as a longterm investment in the economic future of India."

So we must end the drift and call Indian Science and Technology to our aid. India is a potentially rich country with a variety of rich national resources which should be used more fully. Our greatest asset should be the creative talents of our young people. You all know that in 20 years, India has made considerable progress yet we still stand on the threshold of self-reliance. The experience of the past year has underlined the dangers of agricultural stagnation and dependence on foreign aid and know-how especially in the critical fields of industry and defence. We require more trained manpower and must hasten the scientific and technological revolution.

It is at this crucial juncture that we discover amongst the many crises which face us —a crisis of Indian science. It is possible to detect a sense of disquiet and frustration in the country's scientific community of which 'brain drain' is not the only manifestation. There appears to be gulf between science and administration, inadequate contact between science and industry and in my view, foreign collaboration is still too readily sought.

Science and Planning also could draw much closer. There is urgent need for more careful and detailed research planning linked to specific needs and time-horizons. We must be sufficiently bold and imaginative in developing and using our own know-how as well as making the fullest use of the experience of others. Above all, we must ensure that the results we achieve are commensurate with our investment.

Science has long ceased to be considered an esoteric pursuit. It has to be part of the life of every Indian—the jawan, the farmer and worker, the housewife and the student.

May I welcome you once more and hope that the discussion and exchange of views, you will have here, will be fruitful and will help us, well, in helping you. It is not for me to guide or to give you guidelines for your discussions. You are far more knowledgeable and experienced in all these matters. But as I said earlier the real purpose of this Round Table is to put forward certain ideas and certain guidelines as also to get to know one another. Some time ago, a scientist said that one of the blocks in the advance of science in India was that although a large number of scientists went abroad and met their counterparts in other countries, they did not have the same contacts with people working in other areas of science within the country. I think we should also think of a way in which this lacuna could be covered and we should find some ways—not through large conferences or the reading of papers—of just getting together and finding out what the other people are doing and knowing them, so that one has a fuller picture of what is happening all over the country.

Panel I : SCIENTIFIC TEMPER

THERE was an important thread running through all our discussions on science with respect to education and society; *that a large number of competent scientists must get personally involved in these aspects.* The obvious administrative and other obstacles naturally exist but, as has been demonstrated by some of the efforts in this direction, they can be overcome.

SCIENCE EDUCATION

We did not think it was fruitful or possible to have a general discussion of the various problems of education in the country; detailed studies of these exist in the form of the Education Commission Report, and various other reports.

It was felt that a basic defect of our science education at most levels, including attempts at popularisation of science, was the emphasis on teaching about the supposed 'facts' and 'wonders' of science and not the methodology of science. If science is continuously taught in this manner to the bulk of our students, it will *not* lead to the development of scientific temper. Facts and wonders or wonderful 'facts' exist independently of the scientific method; tradition and superstition abound in these. Hence they make very little impact on the devotees of the 'third culture' which includes most people in this country.

This problem is obviously connected with the whole problem of good education—good teachers, good facilities, good books, etc. etc. We could not go into details of various aspects but the following observations and suggestions were made :—

(i) Many of the science text-books prescribed for schools, besides having a wrong methodological approach, contain errors. It was suggested that all books prescribed should be scrutinised by a competent panel.

(ii) Text books should be written by first rate people in each region or State, and these should be made compulsory all through the State. Alternatives can, of course, be provided. Here the responsibility of competent scientist was emphasised.

(iii) Note was taken of the good work of several agencies which are making some of the modern courses in science, developed by several groups abroad, available in cheap editions to Indian students. But some of us feel that at the school level the books need to be translated not only in terms of language but also in terms of their 'atmosphere'. They could conform to an Indian child's experience.

(iv) Scientists in universities and laboratories should take part in school science education. They should establish contacts with the local educational authorities (and vice versa), and in general work in advisory capacity to some schools. One way would be for one or two scientists to "adopt" a school which they can visit a few times a month, help invent experiments for teachers and students, and in general liven up the science teaching. Perhaps *the best* university science students could be asked to teach in primary schools as a part of National Service Scheme if introduced for students.

(v) Science journals at school level would be very useful. School teachers and others could discuss the innovations in science teaching they are introducing, new ideas about building new equipment, new experiments, etc. etc. We are told that a beginning has been made with the journal called "Science Resource Letter' sponsored by National Council of of Science Education.

Popularisation of Science and developing scientific temper

A most important step in developing a scientific temper in the country would have been taken if rational and economic factors alone governed our national decisions, irrespective of parochial and emotional pressures that often arise; the questions of ban on cow slaughter and the location of industrial enterprises are precisely such issues.

Use of mass media

The following steps were suggested:—

(a) Documentary films by the Films Division on the methodological approach to science and taking the assistance of scientists from universities, laboratories etc. in the preparation of these films. A panel of consultants (scientists) for this purpose could be set up by the Films Division.

(b) The proportion of radio talks on matters of science should be greatly increased frcm the present level. This should be both in the regional and national languages. Competent scientists should be encouraged to present science programmes which are imaginative and instructive to schools and to the lay public alike. Station Directors should be given the responsibility of scanning local talent to give these talks. Such scientific talks should be exchanged between stations, especially in the national language so that area of listening is widened.

(c) Efforts should be made to start and support popular science journals in English and in the regional languages and again competent scientists should feel it their duty to widen the base of science in India by putting in time and effort in contributing articles to such journals in the general interest.

Science Education and Language

The panel recognised that while the mother tongue is indeed the most effective way of imparting education, a knowledge of English is today almost indispensable for a career in Science and Technology, in as much as, much of the source material relating to advanced research and technology is being published to an increasing extent in English. It is completely unrealistic to assume that one could have ready access to all this material through any viable machinery for translation. Thus the panel was of the unanimous opinion that English has to be taught sufficiently early to all students who intend to go in for specialised or advanced courses in Science, Engineering & Technology. The medium of instruction for such courses (e.g. post-graduate science courses at universities, engineering and medical courses, and the I.I.T. courses) should at present be in English, as otherwise a very serious and permanent injury to the development of the scientific manpower in the country is bound to occur.

Universities and Laboratories

We considered the question of science teaching in Universities and felt strongly that the funds available were pitifully inadequate for anything worthwhile in research for teaching. It was calculated that even doubling university staff and supporting assistants may not cost more than Rs. 5 crores on a very rough calculation and that such an increased outlay was highly desirable since university teaching and research form the backbone of Indian science.

It is well established that the creative output of any group of research workers is enhanced by the presence of several senior people working in the same field. Therefore it is suggested that universities must build viable groups in selected areas to be able to maintain research activity in those areas at a first rate level. For this an attempt must be made to get together at least 4 or 5 scientists in the given area. While the number of such areas in any given university may be limited depending upon the total resources of the university, they must be fully supported with laboratory facilities, experimental equipment and research studentships.

We felt that scientific personnel and equipment whether located in the universities, laboratories or industries, should be used for teaching, research and other scientific activity freely between one another. University staff should have a *right* to spend sufficient time and use facilities of laboratories and the laboratory staff should spend sufficient time at the universities to establish wider contact with knowledge and to rejuvenate by interaction with young people. No institution should have a completely static staff which is insulated from outside influence.

Provision of joint appointments for national laboratories and universities will be very fruitful. However such an exchange should not be restricted to people who do have such joint appointments. Everything else should be done in the university departments and laboratories to make this exchange as free and easy as possible.

Some research groups in some universities and laboratories have reached a supercritical size and progressively more and more such supercritical groups will develop. Such groups continuously receive requests from scientists in India and abroad to join them but obviously they cannot grow indefinitely. A planned attempt must therefore be made to transplant strong nuclei taken from such supercritical groups —including their experimental equipment —at other universities. We would suggest constitution of small National Committees consisting of members drawn from the UGC, the relevant laboratories and universities who, in consultation with such groups, would make suggestions about possible transplants.

Several steps were suggested to enhance the level of research in the universities :—

(a) The institution of more professorship and other senior posts;

(b) The replacement of the hierarchical system with perhaps a rotating Chairman or Head for a period of 2—3 years;

(c) Institution of funding directly to individual staff members for research purposes on the basis of proposals which could be reviewed by suitable committees; and

(d) The institution of Sabbatical leave as in Western Universitie's for research or study of one's interest.

The present procedures for import of or accepting gifts of foreign chemicals and equipment are extremely cumbersome and should be considerably simplified.

Brain Drain

We discussed the question of the brain drain and feel that this was a national loss and every effort should be made to return Indian scientists to India since there was a need for many more scientists especially at high levels of excellence. It was essential to identify the first rate scientist abroad and allow him to return if he so desired with a team of his own choosing and to a location of his choice where the facilities, which he laid down, should be provided as far as possible. Such people could form nuclei around which centres of excellence could develop. It should also be possible for a senior scientist in India to correspond directly with someone abroad who would be willing to join his group. This system should be strongly encouraged. Such a returning Indian should be offered a suitable appointment. In other words one should find the people we really want and create conditions to absorb them in worthwhile scientific activity in the country.

Different criteria of judgment between Indian and foreign trained personnel should be avoided as it creates an unhealthy atmosphere and has a demoralising effect on scientific work. Also scientists in the modern borderline disciplines, which are rapidly growing, and in which a great deal of research in India is required than traditional disciplines, should be actively encouraged to return.

Panel II : ORGANISATION OF SCIENCE

Preamble

Recognising the key-note of Science & Technology in national regeneration and development, the Scientific Policy Resolution broadly and adequately sets out the aims of Government Policy in regard to Science. To give effect to these aims, to determine the strategy and to chart a concrete course, it is necessary to create and foster effective organs and institutions for realizing the set goals. A practical approach to this problem would include not only augmentation and modification of the existing organisational structure but also the creation of a new institutional framework.

Government must have available to it expert advice on Scientific Policy matters at the highest level and also an administrative structure which transforms its decisions into reality at a speed which the urgency of the situation demands. The Scientific Policy-making Bodies, the National Planning Commission, the various National Institutions for scientific and technological research, the Science Departments of the Ministries and the Universities all form part of an interlocking and complex network of Science which, in turn, interacts with and is part of National industrial, economic and social activity. The panel discussions have centred around the main issues which bear on this question of the evolution of Science Policy and its implementation.

Science Policy and a Budget for Science

(a) *Advisory Component*: It was generally agreed that the SACC should remain the sole body providing top level advice to the Government on science and technology. However, it was felt that to be able to do this effectively it would have to be "activated" through the introduction of;

(1) a full-time Chairman preferably a professional scientist;

(2) the inclusion of the Member of Planning Commission in-charge of scientific research as a Member of the Committee;

(3) a small permanent staff of science analysts covering various scientific disciplines ;

(4) the panel or working group system to tackle specific problems and initiate studies of fields and disciplines in depth. Such panels would enable the Cabinet to secure the expertise of the substantial proportion of the nation's scientific community.

(b) *Executive Component*: The panel felt that there was urgent need to substantially increase the efficiency coordination and speed of implementation of various science policies and programmes. Two organisational approaches for achieving this objective considered, were :

Augmentation and modification of the existing organisational structure.

Creation of a new institutional framework.

National Council for Scientific Research—

The setting up of such a body was considered as an example of the first approach. The Council was conceived as a statutory body charged with coordinating and implementing the research and development activities of the various scientific departments and organisations within the Government. It would be chaired by the Member for Scientific Research of the Planning Commission and the other details, its structure as also its mode of operation might be as follows:

In each Ministry having "significant" scientific and technological operation, a Science Administration Wing would be set up to act as the sole executive machinery for implementing the science programmes of the Ministry. The Wing might be headed by a person with scientific training and understanding of the administrative needs of research and he might be given the rank of an Additional Secretary. However the organisation on the Wing would be in terms of horizontal rather than vertical command structure. Each science administrator would represent his Ministry on the NCST.

The level of allocation of total resources to science and technology (e.g. in terms of a percentage of the G.N.P.) would be made by SACC. The preliminary break down of this sum into various scientific and technological areas or projects and the setting of Inter-Departmental priorities would be done by the N.C.S.T. The Science Administration Wing of each Ministry would then draw up the programme of his Ministry including detailed specifications, time-schedules and resource levels. He would also allocate responsibilities for research, design and development between in-house groups and those in universities and private or public industries where the necessary expertise is available. The various ministerial programmes would then be brought back to the NCST for financial and technical integration without duplication. The Science Budget built up in this way, both for the year and the Plan, would then be forwarded for sanction to the Cabinet.

A Ministry of Science and Technology—The Science Policy Resolution was passed some years ago, but it is admitted all around that hardly any progress has been made towards its implementation. The reason is that there is no existing organisation specifically responsible for piloting the resolution. It is high time that a Minister of Cabinet rank is appointed for the purpose.

The functions of the new Ministry should include:

(a) Providing leadership and guidance to all ministries in regard to identification of areas where scientific research, development and innovation could help in the rapid achievement of social objectives.

(b) Coordinating scientific research in different fields and focussing attention on matters of nodal importance like technical manpower, the survey of natural resources as also initiating measures for the effective utilisation of the proven results of research.

(c) Advising Government on the implementation of scientific policy.

A National Academy of Science and Technology—It was the unanimous view of the panel that the lack of a single professional society for science and technology of national scope was a serious handicap to the growth of science in the country. It was agreed that the initiative for setting up such a society should come from the highest levels within the Government. It was suggested in particular that the Prime Minister might call a meeting of the representatives of the four existing professional societies and work out with them either the amalgamation of their societies or the setting up of a new professional body. The National Academy should operate under a special and specific charter on the lines, for example, of the National Academy of Sciences of the United States. As a single national society could be in a position to generate a fruitful exchange of ideas on matters of policy with both SACC and the Planning Commission, it would, above all, be of immense value in bringing a real national scientific community into being.

A New Approach to Science Administration—Scientific and technological activities constitute a distinct culure and the administrative practices in organisations of scientific research should reflect the flavour of this culture. The following problems need special attention from this point of view:

In personnel procedures, it is essential to have an effective system for discovering talent, encouraging innovations and giving opportunities for individuals to advance professionally through their performance as judged by their peers. The method of operation as regards selection and promotion of scientists by the UPSC, is thus quite inappropriate to personnel involved in scientific research and education. There is also great need to ensure that job opportunities and career prospects in science and technology are not lower than those of other Government Services in terms of economic, social or professional benefits. In this respect, the last paragraph of the Scientific Policy Resolution is still to be implemented. Another area of critical importance in the administration of science is concerned with procedures for procurement of materials. For any scientific organisation, these must be different from normal Government procedures. In particular, once a budgetary provision has been made for a project programme or organisation, no further reference to "Finance" should be necessary. It is also desirable to make financial grants for research block grants covering an appropriate period.

Universities—The principal role of the Universities as centres of excellence in fundamental research and the creation of scientific manpower has already been recognised in the Education Commission's Report. What is necessary and urgent is to implement their strengthening. The Universities, as a matter of policy, must not interpret their activities in isolation from other scientific and technological activity in the country. As a matter of policy the principle of multilateral funding of university research activities should be recognised and implemented. This would allow them to interact with applied science and technological activity in a responsive manner without deteriment to their basic role.

Panel III : PLANNING AND UTILISATION OF RESEARCH AND TECHNOLOGY

1. Indian talent in science and technology is of high quality. When tasks have been assigned with confidence and when full information on the problem is given in clear terms, success has been achieved and such success is essential for further growth of indigenous technology.

2. There are generally ample opportunities for recognition of the work of scientists working in basic research. Special measures should be created to recognise scientists and technologists making contributions in applied sciences.

3. Problems are most easily defined and the results most profitably and speedily utilised, when the user of research is fully associated with research, preferably when the user has a control and stake in research. It follows that industrial research and development is best carried out by industrial units in public and private sectors. All encouragement and incentives should be provided to industry to achieve this. Until industry instals research facilities, national research institutions may help in nurturing such research.

4. National Laboratories have a vital role to play in carrying out basic research of interest to the nation. They can effectively carry out applied industrial research work only if clearly defined problems can be entrusted to them, and full consideration is given to the need for proper facilities and time required for execution of projects. It may be necessary in the initial stages for the laboratories to take somewhat extraordinary steps and go to specific industries and with their assistance, identify problems and eventually sell research to industry.

5. Foreign collaboration may be resorted to only for the purpose of gaining lead time. In cases where technology of a high standard could be developed within the country, such collaboration is undesirable. Even in cases where an industry is established with foreign know-how, R & D support must be given immediately to take such imported technology further. It is also not necessary to have total turn-key imported technology as parts could be quite successfully developed within the country. When foreign know-how is purchased, it should be on a lumpsum, rather than a royalty basis.

6. National Planning for research and development, in a broad sense, is vital. The Bhaba Committee's Report on electronics should be emulated and arrangements should be made for similar high calibre reports and plans for action to be produced by National Committees in other subjects, e.g. petro-chemicals, fertilisers, plant protection chemicals, heavy chemicals, plastics, metallurgy. Clearly laid down strategy and follow up on the basis of such broad plans will produce outstanding benefits.

7. Apparently successful research projects fail at a later stage. To avoid such failures adequate feasibility studies covering technical, marketing and economic

feasibilities should be carried out at an early stage. The final user should be given full information, based on reasonable pilot plant studies and adequate surveys. While Laboratories should instal pilot plants for defining design parameters, they should not operate semi-commercial plants, which are properly the domain of industry and which in such cases could be financed by NRDC with the cooperation of industry. From design parameters, Indian project engineering consultants are quite capable of producing feasibility reports.

8. A clear distinction should be made between Research and Development on the one hand and Design and Engineering on the other. It is this lack of distinction and the expectation that R & D should erect plants that has led to operational failure in the past.

9. Utmost emphasis must be laid by research institutions on quality. The high quality of products developed by them must be clearly endorsed independently by several of the users before such products are said to be acceptable. Equally, consideration should be given to costs so that eventually Indian goods become internationally competitive. In certain areas where health and safety of the public are involved, quality certification should be made compulsory.

10. Suitable fiscal measures should be adopted including selective and varied import and excise duties in order to encourage the growth of indigeneous technology and production.

11. The total quantum of research and development in the country as a whole is still deplorably low. All efforts should be made to increase it speedily. It is unreasonable to expect large and quick economic gains at this level of effort from public research institutions. Some tolerance and encouragement and willingness to define goals clearly rather than harping criticism, will produce results. Eventually research should and will pay for itself.

12. There is considerable technical know-how already freely available and application of these on a widespread and efficient basis can produce substantial benefits.

Papers Presented

Problems of Research and Industrial Development and their possible solutions

B. D. TILAK*

If the results of Research and Development are to contribute to the process of economic growth, they must be reduced to public practice and implemented through industry. Thus the planning of applied science for the benefit of society is closely linked with the various environmental, technological and economic factors.

Even in advanced countries, wherein over 75% of the industrial research is carried out by the industry itself, the reduction to public practice of the claims of Research and Development is no easy task. Hence in a country like ours, where 90% of the industrial research is located in government laboratories, wherein the average industrial experience of the scientific staff is very meagre, the planning and execution of applied research poses great problems. If the results of our indigenous Research and Development are to be implemented for the benefit of society, there ought to be a very close link between research and industry.

The main acts involved in applied Research and Development are (i) problem identification (ii) laboratory and pilot plant investigations (iii) industrial application of research results.

Problem identification

This is the most vital and possibly the most difficult step for our laboratories. For right choice of an industrial problem for Research and Development, it is essential for scientists in our laboratories to closely associate with leading industrialists and their technologists, managers and marketing staff. This liaison may be achieved through advisory panels, executive councils, visits to industrial plants, industrial consultancy at an individual or institutional level etc. By establishing close links with industry through these media, the laboratories will be able to identify problems for Research and Development and in addition will also be able to weed out infructuous projects and improvise their research methods.

In spite of various steps which the CSIR Laboratories have taken to ensure cooperation of the industry both in the private and public sectors for the purpose of identification of problems for research and development which may make an impact on the industry, the above industries have been rather slow in taking advantage of the Laboratories for carrying out work on specific projects. The emphasis still appears to be for seeking foreign collaboration not only for new developments but also for expanding the existing production. Whereas no one can deny the need for the industry seeking foreign help in science and technology as well as finance for the establishment of very large industrial projects, there is still considerable scope for our Laboratories providing know-how for a large number of other items. The indus-

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tries both in the private and public sectors will change their present dependence on foreign know-how only if the Government gives a lead by formulating a policy which will earmark areas for foreign collaboration and those for indigenous development.

It is suggested that the Planning Commission may establish cells for drafting a plan of development of various industries. Specific industrial projects to be established in the coming five years should be identified. These should be divided into two categories, one where foreign collaboration is sought and the other where industrial capacity should be established only with indigenous know-how. In the case of the former, negotiating teams for purchase of know-how should be formed consisting of Government advisers, members from industry and scientists from the research laboratories in the country. Indian scientists and project engineers should be closely associated when such industries are established with foreign collaboration. As regards the industrial enterprises which are to be earmarked for development with a totally Indian effort, the Planning Commission scientific and technological development group may take the initiative for bringing together such industries as may be qualified to undertake this development and the relevant scientific groups in the country for a joint effort for such development. If the developmental work is of national importance the Government should, if necessary, even finance such work in private industry if the latter is the best place to do such work and if the industry is unable to finance such effort on its own.

The Planning Commission should establish expert groups to continuously look into the current problems of the industries as well as the problems of future development such as their difficulties as regards customs, tariff, exports, etc. to ensure healthy growth and development of industries.

The task of problem identification will be very much simplified if research and industry get together in close partnership even before the start of applied work. An excellent method of ensuring success of applied research is by motivating industry to entrust to labortories contractual research on payment. Ours being a planned economy, it should also be possible for the laboratories with the help of Government planning machinery to decide in advance and plan the future actions towards import substitution, export promotion, and development of indigenous technology for prospective industrial development.

The scientific and technical advisers to the Government in the different ministries and the DGTD as well as the Managing Directors of Public Sector Enterprises are in a position to materially assist the country's march towards industrial progress and self reliance if only they would take a positive interest in the work of the Government research laboratories by framing out problems for Research and Development in advance, so that the laboratories would be ready with know-how when it is actually needed for installing industrial plants. Barring a few exceptions, this has not happened and the concerned Ministries should take positive steps in this direction. On the part of CSIR, such assistance is keenly sought by inviting such experts from Government to serve on the research policy making bodies of CSIR at Headquarters as well as in the Laboratories.

Laboratory and pilot plant investigations

For development of new chemicals, considerable applied basic research needs to be carried out. However, for hundreds of other chemicals, which India imports and which are well known there should be no serious difficulty in developing indigenous technology for their manufacture.

The laboratory scale data should be tried, wherever required, on the pilotplant scale to obtain the necessary design data, to decide the material and energy balances, layout of plant, etc. The chemical engineering data, of course has to be converted into the mechanical engineering drawing and followed by fabrication, erection and operation of the plant. For this purpose the laboratories should take the assistance of well established project engineering firms who in turn will be in a position to offer turn-key plants to prospective users of research if necessary with guarantees for performance.

The whole tempo and speed of work in the Government laboratories, as against research laboratories attached to industry, is generally rather slow. The scientists in our laboratories are not adequately alive to the importance of targets and budgets and the association of men of varied specialisations into a task force needs to be achieved. To some extent such a situation is inevitable when research and industry are not established under the same management, as in the case of socialist countries, or under the same premises and management as in the advanced countries in the West and East. This limitation has to be realised when one judges the usefulness and performance of our governmental laboratories. The Government may seriously consider associating some of our Laboratories with user Ministries so that the problems of science and technology pertaining to the activities of these Ministries could be effectively tackled.

Industrial application of research results

In view of the traditional preference of foreign know-how by our businessmen, who have lately been only traders, the CSIR and other such laboratories have a really uphill task in motivating industry to adopt technology developed by them. In addition to the above difficulty, the Indian and foreign financial institutions are also most reluctant to help the entrepreneur who ventures to adopt indigenous technology. Many entrepreneurs look upon our governmental laboratories as unnecessary white elephants and are more than critical when they are obliged to adopt technology developed in the laboratories when foreign collaboration is denied by the Government. Our failures are magnified to support the argument for more and more foreign known-how.

In view of the above unhelpful atmosphere prevailing we have to be very critical of our own effort before we approach industry.

Indian industry is often interested in getting a turn-key job supported by full guarantees and insurance against shortfall in plant performance. Laboratories in collaboration with reliable engineering firms can fulfil this need as well.

Incentives for indigenous know-how

The Government may consider several incentives for entrepreneurs who will be establishing industrial capacity with indigenous know-how by giving a free market for exploitation for a limited period of time, tax concession, foreign exchange release or essential equipment, etc. It is also necessary that such units should be given financial assistance by financial institutions which are somewhat reluctant at present to support industries established with indigenous know-how.

(Contd. on page 21)

SCIENCE ROUND TABLE

HARI BHUSHAN*

I shall confine my comments mainly so far as science and technology are applicable to the industrial field. The Scientific Policy Resolution of 1958, of necessity, had to be in general and broad terms and may be considered adequate as such. However, the yard-stick for judging either the adequacy of the Resolution or its implementation should rest on the evaluation of the results achieved in the last ten years. I feel that implementation has particularly fallen short with regard to (ii) and (vi) of the Resolution†. There are a number of circumstances and reasons which may be attributed to our failure. Some of them are within control whereas on others we may not have had complete control. As a result, whereas we are finding in the country a serious shortage of scientists of high calibre and quality, they are able to find highly remunerative, responsible and satisfying jobs in foreign countries and there is a regular, large-scale flight of our scientists and technologists to foreign countries. In the context of modern science and technology, the world is getting smaller and smaller and indeed has already shrunk very much. It is difficult to make comparison of scientists and technologists with their counterparts in various other countries with whom they come in close touch. Some of the countries which have a high standard of living and which are in fact able to save considerable expenditure in bringing up of a scientist to the stage where he can contribute, find it possible to offer very attractive terms, in fact several times the salary which our scientists and technologist can get in this country. In the context of the poverty and extremely low levels of incomes in our country it would be futile and even unreasonable to argue that they should be paid salaries and emoluments commensurate with what they can get abroad. However, despite this it should still be possible to retain our scientists and technologists and in fact even attract those of our countrymen who are serving in responsible positions abroad, *provided* however, it is possible to give them job satisfaction. Firstly, the scientist should be given jobs in which he has real interest and for which he has aptitude. Secondly, by temperament, he would find administrative delays and procedures, sanctions etc. as very irksome. As a first measure these need to be streamlined. Secondly, perhaps there is no satisfaction and joy comparable for a scientist or a technologist when he sees in actual translation the fruits of his labour. In India, whatever little I have seen, I cannot help observing that there is, at present, very limited scope for such satisfaction. There are a large number of cases where the scientists have laboured over a long period to bring out some innovation or invention only to be frustrated at a later stage because there were no means to translate into actual practice and put them into actual use and operation or what they did, was swept aside through import of foreign technology. In the earlier stages of the industrial development of the country it was probably advisable and prudent

* Planning Commission, New Delhi.

† See Annexure III at end.

to secure technology and equipment from abroad to set up manufacturing capacities which a modern society needs. In future, the problem may be simpler when we would have developed as a modern country with comparable scientific and technological base as well as manufacturing capacities. However, it is in the present context when we are midway, when some of technologies, process know-how and fabricating facilities are available in the country whereas some of them are missing, and it is in the combining of the two in the best interest of the country that difficulties come up. I feel that instead of gradually weaning away from abject dependence on foreign countries for technology and equipment, we continue to depend very largely on them.

There are two basic factors which would appear to me amongst others to be responsible for this. Firstly, although it may sound platitudinous, it is a general lack of *swadesh* spirit in the country. I have known English couples hunting the market in India to find articles made in U.K. and Germans looking for German-made articles. In contrast, I find that we generally look whether in India or abroad, for articles and equipment made in foreign countries and not in India. The same preference for foreign-made things seems to pervade right from shirts and nylon sarees to the steel plant equipment. I feel that not sufficient awareness is being shown of the damage that such a spirit can do to the country's interest. Something has to be done to change this psychology. Naturally it is to start from the top. Not until the Ministries themselves, particularly in the public sector project, give up their efforts to import as much as possible and in fact show marked preference for indigenous equipment despite certain drawbacks, that we can expect others to follow suit. With their preference for everything imported, it will be inadvisable at this stage to leave the choice of importing technology entirely in the hands of the entrepreneurs.

The second important factor is the lure or the *mrigmarichika* of the availability of foreign credits on easy terms of interest and repayment. We can go after the golden deer but will get our grahlaxmi stolen. Firstly, it is important to realise that the term "assistance" by foreign countries is somewhat a misnomer. What is offered to us is credit leading to indebtedness. Just as we are in need of imports, the economies of the developed countries are equally, if not more, dependent on exports. Not sufficient note has been taken of this aspect in order to have any bargaining advantage. We are heavily debted today. We are even asking for further credit to pay the interest on our debts. Under the difficult foreign exchange position, when foreign credits are available, what is mistakenly believed is that they are highly beneficial to the country's economy and therefore must be utilised. The result is that the factories in those countries are running to full capacity. They have high employment opportunities and shortage of labour. They have booming standards of living, and we seem to be anxious to utilise these credits even if it means running our factories at less than half the workload—factories set up at high cost of taxation and foreign exchange expenditure with idle and dis-satisfied labour, lay-offs etc.

The attraction of credit combined with the preference for the imported technology, equipment and foreign experts exclude to a large measure the scope of the fruition of the hard work and labour and consequently job satisfaction which our scientists and technologists so badly need and which can only perhaps provide sufficient attraction to retain them in the country.

I would like to cite a few examples which are only illustrative, but if necessary, a very large number of such examples could be furnished. We continue to engage the services of foreign technologists and consultants for a number of preliminary and other studies, such as pre-investment studies for setting up structural and pipe plants, alumina plant etc. for feasibility studies, critical path technique, compilation of data etc. and even location studies. Our own technologists who have a far better familiarity with the local conditions—and now we have a number of consultancy organisations which have come up in the country equipped to carry most of this work—could carry out these assignments better and, what is more in the process, gain experience and stature. The experience gained would remain in the country and not go out of it, after the studies are completed. Let me give an example: a foreign firm of consultants was engaged to advise us on the compilation of industrial data in the Directorate General of Technical Development. I have gone through the report which is simple and elementary, which many of us with a training of a couple of months in the field of computerization of datas could have successfully done and perhaps in a better way. Instead of the firm of foreign consultants if we had selected one or two of our own officers in the Department and sent them out for training for a few months and asked them to attempt the same exercise, put them on the implementation and linked them with its success or failure, I have no doubt that, in the process, we would have created a couple of experts of the highest calibre. We would have ensured the success of such a measure and incidentally would have also saved foreign exchange. Today we are engaging the services of foreign technologists over a very wide field whereas similar work could be done by our own people. It will be worthwhile to go deeper into the matter and to evaluate the dissatisfaction and frustration that it creates amongst our own technologists.

In conclusions to what I have mentioned above, I would say that necessary climate and conditions could be provided for scientists and technologists to give them at least the necessary job satisfaction when we cannot afford to pay them very high salaries. I shall go further to suggest that we should locate Indians working in responsible positions abroad and keep a roster of their particulars. Requests continue to come very often both from the public and private sectors units for engaging the services of foreign technologists. If we have such a roster we could attract our own Indian technologists and scientists working abroad in preference to others.

Much can be said on the objective of self-reliance with regard to science and technology. Examples are given of the most advanced countries where there is a full inter-change of science and technology between them. Firstly, a relationship when we are only at the receiving end, not at the giving end, is not comparable to the free interchange of science and technology between the advanced countries. Secondly, we are to a make a clear distinction whether :—

(a) we are importing the technology only if it is a better one and not already available in the country and that it is suitable for the scale of production and the raw materials as available in the country, and

(b) Does this import of technology bring in its train large credits, turnkey jobs, complete design and engineering done abroad, even the supervision of civil works, the errection and commissioning done by the foreign party and the import of bulk, if not all, of the equipment?

If we must import know-how and technology, there need not be any serious objection to it. As rightly pointed out in some of the papers, it might perhaps contribute a small portion of the project. However, as I have mentioned earlier, if along with the import of technological know-how we have to import all that I have stated above, the country indeed would be paying a very heavy price for its progress and we are already faced with a dilemma whether we can pay this price.

The object of self-reliance is, therefore, real and meaningful. We may define it as limiting our reliance on the import of science and technology only to that extent which is not available in the country. We must strictly avoid the import of technology to serve as a thin end of the wedge and the import of all kinds of equipment which we can manufacture, thus avoiding large foreign debts.

If we are able to achieve a good measure of success in achieving self-reliance we may also be able to achieve the associated object of preventing braindrain from the country. Our scientists and technologists, as well, will discover that they need not always work under the supervision of foreign experts but can themselves occupy important and responsible positions and achieve concrete results in the exciting task of building a modern and prosperous India.

With regard to the question of the extent of the limits to which foreign collaboration is put, sought and encouraged, we have already available with us the Study Report of a Committee under Shri Rama swami Mudaliar. I am, however, not sure whether it has really furnished concrete answers to many of the problems. One of the important problems on which we should like to take the opinion of our experts who have collected here, is the avoidance of importing foreign technology repeatedly for the same process and for the same end-product. Mostly the agreements are bilateral and the party which receives the technological know-how is not entitled to divulge or to pass it on to the other parties. Every measure, therefore, needs to be thought and taken to break this situation. We do not know how it is done in Japan where technological knowhow is imported once, where it is repetitively used and improved upon for further exploitation. Every measure that can be taken to get over this problem would be worthwhile. Some of these measures could be—

(a) Import of technology through consultancy organisations,

(b) Entering into agreements which, to the extent possible, allow setting up of similar units with the same technology by other parties,

(c) Making use of the expert personnel engaged in one plant and setting up other similar plants elsewhere in the country,

(d) Setting up of standard size plants,

(e) Fiscal incentives to attract the unit to part with the technology and pass it on to a competitor.

I am in general agreement with the various suggestions and points which have been made out in the paper circulated by Dr. Y. Nayudamma.*

* See page 64

The need for science and technology to fertilise and feed our industry is amply recognised. A number of studies have been made and discussions held. I would like to make one suggestion for consideration. There appears to be a certain psychological gulf between the large National Laboratories set up by the Government and the industry which neither puts in sufficient efforts of its own toward research and development, nor is it anxious to make the best use of the results flowing out of the National laboratories. It is said on one side that the research in the National Laboratories is not industry-oriented and on the side that industry is spoon-fed and dependent on foreign technology and know-how. It finds it easier to pay for such technology to the foreign experts rather than take adequate steps to at least gradually build up their own infrastructure and base for such technology.

One of the fringe problems which will lend itself to a comparatively easier solution is that the industrial units, the manufacturers' associations as well as National Laboratories should pay much greater attention to set up and exploit the facilities for the testing of materials and components and performance of finished products. Much of the improvement in the current manufacturing practices can be effected through rigid control and desire to improve on the quality of raw materials, components and thereby the performance of the finished products. This, by itself, can have at least some impact on the import of technology for improved products. There are certain suggestions such as that of the Indian Electrical Manufacturers' Association to set up a chain of testing laboratories. This needs encouragement. Other manufacturers' associations should also be persuaded to set up similar facilities. The doors of the National Laboratories should also be open for carrying evaluation tests and other tests. Those items of equipment which are very expensive and are installed in a few places should be advertised and the industry, in general, should be made aware of the existence of such equipment. Recently, I happened to enquire the progress of manufacture of spare parts by one of the leading public sector organisations. I was told that the mere analysis of the composition of the ferrous materials took them about two months. I pointed out that next door at the Durgapur Steel Plant there was an electronic equipment which was able to give the chemical composition of the ferrous materials within seconds. A similar unit is installed with Mukund and may be with other steel plants also. In the import-substitution in the development of the manufacture of spare parts etc., such problems are bound to arise every day. The expensive equipment available in the country should be advertised and put to the maximum use. It may even earn some income for those who have this equipment.

Arising out of the above, it occurs to me that there are two sets of industries, those which are having foreign collaboration and buying royalty etc. ranging from about 3 to 5% in the net outgo of foreign exchange, from about $1\frac{1}{2}$ to $2\frac{1}{2}$% or more, and the other group of industries which do not have any foreign collaboration but which are equally in need of constant improvement of their products. Would it not be possible to consider allowing such units, that is, those which have no foreign collaboration, a nominal foreign exchange of about 0.5% of their sales and to allow a free hand to them to use it for such purposes as the import of improved raw materials for prototypes, prototye equipment itself, testing equipment, books and journals and even foreign personnel.

Incidentally I had come across an article in the magazines that in order to cope with the technical problems faced by the Peace Corps volunteers all over the world, the scientists and technologists in a certain place where there was a large concentration of industry, formed themselves in a volunteer organisation. Problems were posed to them by the Peace Corps volunteers which were immediately referred to the appropriate persons and solutions to the problem were promptly sent to the Peace Corps volunteers. We have a large concentration of scientists and technologists in some of the big industrial towns such as Ranchi, Durgapur, Bombay, Calcutta etc. Perhaps we can enthuse the scientists and technologists to make themselves into a voluntary organisation in such places, to whom technical problems could be referred, may be by the small scale entrepreneurs or by large industries, and who could tackle these problems and find solutions for them.

(*Contd. from page 18*)

Investment in Research

It is generally agreed that investment in research and developmental activity by industry is of a much lower order than industrially advanced countries. If the pace of progress is to be substantially accelerated, Indian industry will have to invest far more in R & D than at present. In view of the diversity and magnitude of such problems, the governmental laboratories alone will never be able to tackle all such problems. The industry will have to establish their own laboratories for R & D to solve a majority of their own problems which are in the nature of trouble shooting, expansion of capacity, simple extension of manufacturing programmes, etc. Indeed for such kind of problems the industry is far better equipped to carry out R & D than the CSIR and other laboratories who are at present being called upon to do such work. The latter laboratories should be really called upon to carry out work on forward technology needing an inter-disciplinary approach by a band of highly trained scientists working with highly sophisticated equipment and other facilities.

Although some Indian industries are now investing increasingly in R & D, a large majority do not carry out any R & D work. As a result, efficiency of industry is generally low. It is also the experience of the author that industries with R & D laboratories of their own are also able to quickly and efficiently translate the results of R & D arrived at in CSIR laboratories into industrial practice.

In view of the above considerations the Government should seriously consider the suggestion of enforcing a levy on industry to set aside funds for R & D (suggestion made at the CSIR Get Together with industry held in December 1965). The funds so earmarked should be collected by Government *only if the industry does not spend it on R & D within its own campus or elsewhere* (by supporting sponsored research in CSIR, University and other laboratories). If Government takes this bold step it will be materially forcing the pace of rapid industrialization of the country and also increasing the technological competence of the industry.

Round Table of Scientists and Technologists

Jagjit Singh*

Eradication of Poverty

If we are still poor in spite of some very impressive gains of the past two decades —increase in food production (80%), power generating capacity (400%), steel production (450%), industrial production (200%), transport capacity (300%), telephones (1000%) etc.—it is because all these gains have been all but neutralised by our fast growing population as well as still faster rising expectations. Lack of scientific outlook in the masses inhibits the speed of vasectomy and other birth control measures while adult franchise fans their expectations sky high. Unless the demographic flood is checked, most of our national effort towards eradication of poverty will be neutralised. The relevance of scientific and technological *research* to eradication of poverty is, therefore, not that total as is usually presumed. We need even more scientific outlook on a *mass* scale not scientific *research* to deal with the problems of population, change of food habits, cow slaughter, and above all control of consumption, whether conspicuous or otherwise to accumulate capital etc. Their relevance to eradication of poverty is still greater.

Scientific Policy Resolution

This resolution is adequate. But the institutions created to implement could have yielded more impressive dividends but for certain weaknesses that got built into them right at the outset. A basic weakness resulted from the tacit assumption made at the very inception of C.S.I.R. that by building a chain of national laboratories under it, we shall automatically have a broad base of scientific and industrial research able to help industry and industrial development. The experience of the past two decades has shown that barring a few institutions like the Leather Research Institute, this expectation has not materialised. It is true that a number of patents have been taken out by the national laboratories. But this is no index of effective industrial help rendered. The real test is how many of them have actually been adopted by the industry. Judged by this test, the performance, by and large, is not too good.

The reason for this ineffectiveness is best understood by a comparison of the working of the Atomic Energy Commission and the CSIR. AEC first looked for men and then built facilities round them with a definite goal of developing and duplicating high level of nuclear technology rather than original fundamental research. CSIR, on the other hand, first built a chain of laboratories dealing with all sorts of disciplines ranging from physics and chemistry to ceramics and drugs and then looked for men with "minimal" qualifications to fill them.

As a result, most of the scientists of CSIR trained abroad, brought back with them the problems on which they had been working and naturally continued their work on these problems. Nor could they be easily motivated to tackle problems of

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Indian industrial development because of the absence of indigenous criteria for evaluating research and according it national recognition. Because we recognise the scientific merit of a scientist even now only after he has been recognised by someone abroad, the temptation to occupy oneself with fashionable problems of basic or fundamental research, which alone impress foreign scientists became all but irresistible as is still the case.

If we are to orient the research effort of the national laboratories towards applied research to develop indigenous industry we need:-

(*i*) to substitute indigenous criteria of research evaluation so as to wean the research worker from this firm belief that national recognition comes only if one is recognised abroad.

(*ii*) to limit basic research to only "paper-and-pencil" research as in theoretical physics or mathematics. For the rest each laboratory must be transformed virtually into an R & D unit of a group of industries like National Metallurgical Laboratory, for Steel Industry, CMRI for the Engineering group of industries, and so forth. They should then pick up specific research projects after proper evaluation and progress it with the industry calling the tune. Tendency to overload the laboratory with too many projects beyond its resources of manpower should be resisted.

(*iii*) to strengthen the base in our national laboratories. Experience of the R & D units of large industrial concerns in U.S.A. has shown that bulk of new research ideas—almost three out of very four—emanate from research staff members themselves provided they work in the industry concerned. This is because the R & D is well staffed with *teams* of competent scientists in adequate numbers down to the lowest level. This, therefore, requires that we have to build closely knit teams of competent scientists in each laboratory and not merely have a distinguished scientist at its head.

(*iv*) to abolish "bureaucracy" in the C.S.I.R. that is greatly attenuating the capacity of national laboratories to do useful work. They need to have greater autonomy and more liberal treatment than they have had so far.

(*v*) to provide trained manpower for manning of laboratories as well as industry by what are called qualified scientists and engineers or QSEs of which many key industries are still desperately short. Our colleges and universities and even technical institutes still produce too QSE's of the right type. This is a task which the universities, through UGC and industry, have to handle.

Collaborations

But even if we succeed in moulding our laboratories in doing all they can for our indigenous industry, it must be conceded that they are equipped at present to attempt only those goals which can be achieved by recourse to what has been called low technology involving small improvements in widely used products such as in the field of housing, road-making, food, drink, textiles, leather, etc. Developing countries, like ours, cannot afford to neglect high technology. This cannot be acquired indigenously. It must therefore be borrowed as we borrow capital and thus take advantage of what has been worked out, often at great cost, by those in the lead. It is not possible to imitate high technology by importing a model and then duplicating it as the Japanese tried to do in the twenties and thirties before World War II. They found that limitation led to production of shoddy goods which could not be marketed. Profiting from this experience they have gone in for wholesale collaboration in the matter of setting up high technology. We should have no inhibition in allowing large international corporations to set up high technology in our midst by making it worth their while to do so. For it is a feature of high technology that it is only large international industrial concerns which are able to deploy the scale of effort required to set it up. For high technology it is size that counts—the size of market, of interdisciplinary concentration of technical know-how, of financial resources for both R & D exploitation. This is the nature of technology gap. It is a gap not of intellectual capacity but of available resources and ability to deploy them. It follows therefore that while everything should be done to secure their collaboration at as favourable terms as possible, there should be no artificial or ideological bars such as a fixed 51 : 49 ratio in the holdings of the joint ventures under contemplation. Merely because the international corporation holds a majority share of a joint venture, does not mean any impairment of national sovereignty. Many U.S.A. corporations own subsidiaries in U.K., France, Western Germany and elsewhere without impunging the sovereignty of those nations. Another advantage of such subsidiaries is that they even market the goods produced to the parent country. As a result we shall be able to ensure quality and marketability of the indigenously manufactured article.

Science Plan

Finally we need a National Academy of Sciences enjoying the prestige of the Royal Society in U.K. or that of the National Academy of Sciences in the U.S.A. For we do need a plan for science if we wish it to fulfil prescribed national goals. This cannot be done by a purely governmental body. As Cyril Hinshelwood, a past President of the Royal Society said some years ago,

> "The subtle coordinating action of an academy can no more be replaced by a bureaucratic organisation or a system of economic incentives and deterrents than the intricately evolved biological controls of a living organism can be replaced by crudely devised mechanical appliances."

We have yet to evolve such a truly national academy. That is a problem we can hardly afford to shirk any longer. For if we had it, we should not have called this round table conference at all.

Another advantage of such an Academy is the fact that such men, having reached the ultimate of national recognition, would be under no temptation to build personal empires to the detriment of the nation. They could, therefore, provide effective check to the empire building proclivities of many a director of the National laboratories. They could also act as selectors for selecting right type of men to man the laboratories. The rub, however, is how to select these selectors.

Development of the Interface between the National Laboratories and the Universities

Yash Pal, B. M. Udgaonkar*

The Interface between the National Laboratories and the Universities has been one of the sadly neglected interfaces. Several national laboratories including the laboratories of the C.S.I.R., the laboratories of the D.A.E., the Tata Institute of Fundamental Research, the Saha Institute of Nuclear Physics, the Physical Research Laboratory etc. have grown during the post-independence period and some of these are internationally recognised centres of research in a variety of areas. On the other hand, while the number of universities in the country has increased quite substantially, they have on the whole (barring a few notable exceptions in a few areas) lagged behind the national laboratories in the quality of research carried on in their departments—which naturally reflects in the quality of teaching imparted by these departments. This has often led to the statement that the big national laboratories have grown at the cost of the universities. Such a statement presupposes that scientists who have grown at some of these national institutions would have automatically grown at the universities in the absence of these institutions. We wish to point out that this is not the case and that, on the other hand, the methods adopted by some of these institutions, and the scientific research groups that have grown there as well as at a few of the universities, should be utilised in a planned fashion for nucleating similar groups at other universities.

Scientific research in the country has become increasingly broad-based in recent years and the way activeres earch groups have grown in new areas, is quite instructive. Drawing upon the experience of some of the organizations familiar to us, it can be stated that usually these groups were grown around individuals who were carefully selected and then given all facilities (with the minimum of official red-tape) and freedom to gather other individuals around them, to get some of them trained abroad if necessary, so as to reach a viable or critical size as soon as possible. The importance of the critical size of a group has to be emphasized since it does not seem to have been recognised by most of our universities (again barring a few notable exceptions like Delhi University). In a rapidly advancing area of research, single isolated individuals are very considerably handicapped. They need a continuous interaction, by way of discussions, criticisms and encouragement, with other individuals having similar interests. It is therefore very important to concentrate a few good scientists in a given area at one place and let them grow to a critical size, rather than let them spread thin over different institutions or universities. The present policy of most universities seems to be to keep the number of senior posts at Professor's or Reader's level in any given department very limited and, moreover, the tendency is usually to divide this limited number of senior posts among

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various branches of the subject—e.g. a university which has four readerships in physics may have one in nuclear physics, one in solid state physics, one in electronics and one in spectroscopy. This has several bad effects.

(*i*) good scientists have often been reluctant to go to a university for fear of isolation and have tended to concentrate at the national laboratories. It is to be remembered that until recently the fear of isolation was acting as a deterrent even when scientists were contemplating a return from abroad to one of the national laboratories. Fortunately that has disappeared in many cases.

(*ii*) Those who have ventured to join the universities, have often lost courage and migrated abroad, or stuck on but lost initiative and productive capacity. There have, of course, been a few notable exceptions.

Our proposal therefore is the following :

(a) Universities must try to build critical or viable groups in selected areas so as to be able to maintain research activity in those selected areas at a first rate level. For this, an attempt must be made to get together at least four or five scientists in a given area—say, one Professor, two Readers and two Lecturers. While the number of such areas in any given university may be limited, they must be fully supported with library facilities, experimental equipment and research studentships.

(b) Some research groups in some of the national laboratories and also in a few universities have reached or are about to reach a supercritical size and progressively more and more such supercritical groups will develop. Moreover, such groups, just because of their supercritical nature and the reputation which goes with it, are continuously receiving requests from Indian scientists abroad who would like to join them, and are often forced to reject such requests because they cannot obviously grow indefinitely. A planned attempt must therefore be made to transplant a strong nucleus out of such a supercritical group—including any scientists from abroad who are intending to return and have been interested in joining this group—at another university.

(c) Recently there has been a suggestion that some of the national laboratories must concentrate on applied research rather than pure research, the latter being supposed to be more suitable for universities. We do not wish to go into the merits of this idea but would like to emphasize that a positive approach be adopted in implementing it whenever the occasion arises.

For example, if for some reason, a decision is taken to discontinue a particular activity at any national institution where a competent group in that area of activity has been painfully built up over a period of years, attempt must be made to transplant this group purposefully to a university. Otherwise there would be a danger of this group dispersing abroad. This has been known to happen in the past.

(d) The U.G.C. could play an important role in organising such transplantations —locating prospective transplants, selecting the proper university, inducing it to accept the intended group, and providing it with the requisite facilities and continued support. We would suggest the constitution of small national committees, consisting of members drawn from the U.G.C., the relevant national laboratories and from the universities, which would make recommendations about possible

(*Contd. on page 31*)

A Proposal for Inter-disciplinary Brains Storming Camps

Yash Pal, B.M. Udgaonkar*

We wish to propose here a possible method to achieve a more efficient utilization of the available scientific *thinking power* in the country.

The number of competent and "concerned" scientists in the country is substantial and is growing rapidly. This does not seem to be realized by the authorities when seeking advice or opinion. Only the very busy top men are always called in. This means.

(a) a non-utilization of expert and disciplined thinking power in the country;

(b) non-involvement of a broad but competent level of young scientists in socially important matters and their condmenation to a continued ivory tower isolation, followed by the question as to whether the country can afford to support their "pure" research.

The good people in science develop two important faculties in addition to acquiring the specialized competence specific to their field of research:

(*i*) They learn to question established procedures, theories and even supposed "facts"; further they learn to question these in a meaningful way which can lead to new and more fruitful procedures or theories, and an accumulation of new facts.

(*ii*) They are, or at least should be capable of thinking logically ("scientifically") about any problem, and of analysing it into its component parts, without being overwhelmed by the difficulties of the problem.

We believe that the country must make use of these faculties of scientists. So far one has usually thought of the use of scientists only in terms of their special expertise. But scientists are not just technicians. Among them are many with a motivation who could also think profitably about areas outside their speciality. Some of them would in fact enjoy the intellectual challenge involved.

We suggest that one way of involving this class of people in a purposeful national endeavour would be to organize *Inter-disciplinary Brain-storming Camps* in which the participants are assigned some well-defined problems and asked to come out with concrete suggestions for solving them. These brain-storming teams would operate something like this. Suppose the sponsoring authority wishes to get a report on a topic like the Immediate Utilization of the Underground Water Resources of the Gangetic Plains. Then they would appoint a convener who would invite about half a dozen to a dozen persons from various fields—geologists, chemists, economists, engineer, theoretical or experimental physicists, even pure mathematicians. They may be given a few months for preparation, during which time (while doing their usual work) they can acquaint themselves with the problem, collect information, ex-

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change notes and formulate specific questions for intensive study and discussion. Then they would spend a few weeks together in one place, during which period they would live with this problem and come out with a report. The interdisciplinary aspect of this study-group is to be emphasised. Involving competent thinkers from various disciplines, is important for ensuring a fresh outlook on the problem. Besides contributing valuable studies on the assigned topics, interdisciplinary contacts established in this fashion will be invaluable both socially and professionally. In addition, this procedure will inculcate a social involvement on the part of a significant thinking section of society.

We list below, just for illustration, some topics for such brain storming camps.

(*i*) The Monsoon: What do we need to know in order to minimize the effect of its vagaries on the crops? Can we predict the date of its commencement ? What meteorological and other studies are needed before we can make this prediction ?

(*ii*) Soil Conservation

(*iii*) Utilization of Water Resources

(*iv*) Wastage of food grain in Transit and Storage, and the means for minimizing it.

(*v*) Popularization of Innovations in Agriculture

(*vi*) The Interface between Industry and Research Laboratories

(*vii*) The Interface between Universities and Research Laboratories

(*viii*) Other Interfaces

(*ix*) Economic, Political, Social, International and other Aspects of a decision to embark on an Atomic Bomb Programme

(*x*) Specified Aspects of Defence Strategy —etc. etc.

We would like to emphasize that we are not talking here of a conference of specialists, or of a committee of specialists on a given topic. We definitely imply the involvement of thinking people from various disciplines in problems in which they have never worked before. The important thing is the *intensive* thinking by people who are capable of viewing the problem from new angles.

This programme does not need any large expenditure. The necessary people exist. We have only to invite to get together and concentrate their thinking for a while on a specified problem of national importance. They would be grateful for the opportunity and only good can come out of it.

(*Contd. from page 29*)

transplants. There has also to be a proper machinery to implement the recommendations made by these committees.

(e) We are aware that such an action initiated by a national committee may be interpreted as an interference with the autonomy of the universities. But one of the functions of the U.G.C. by its charter is to ensure adequate standards of research and teaching at the universities and it should therefore not hesitate to step in if the autonomy is being used by a university merely to perpetuate its mediocre status.

(f) Another possible hurdle to the initiation of such a programme would be a disturbance in the so-called parity between the various departments of a university. It is obvious that all departments cannot be upgraded simultaneously and that strict parity can exist only in a static situation. This has already been recognized by the U.G.C. in setting up various centres of excellence, and by the Education Commission in its suggestion to single out five or six universities for development as major universities. In fact, our suggestion of transplantation could be used for creating new U.G.C. centres and/or strengthening departments in the selected major universities.

SCIENCE AND THE NATION

V. B. CHIPALKATTI*

1. The Role of Research and the Research Scientist in National Development

No one would dispute the need for using science and technology for the eradication of poverty or for the promotion of a scientific temper to circumvent ignorance and superstition. It must be realised, however, that implementation of this policy has to be tackled on a wide front. This includes education, academic research, industrial and agricultural research, industrial and agricultural development to include building up new factories and farms for more production, building and buying new machines and equipment for new units of production and so on.

Scientists, Technologists and Engineers have to play a vital role in this endeavour, but this role is not limited to researchers alone. In fact, scientists, technologists and engineers engaged in industrial establishments and engineering workshops etc. have a far greater and more direct role to play. This point is usually lost sight of in many a gatherings.

2.0 Self help not always economic and feasible

It is not necessary to compel a new factory or an agricultural farm to use Indian know-how if it is not economically or technically or entrepreneurially feasible. Whenever foreign know-how is available on acceptable terms, it enables activity to be based on confidence and the scale of operation and the time required for implementation are both favourable to national development. Japan, West Germany, U.K. France, Switzerland, USSR and many East European countries have depended on foreign know-how even when they were economically far more developed than India. It is highly dangerous, therefore, to make a popular slogan of self-reliance in science and technology. Such slogans mislead not only the lay public but also the politicians, economists, government officials, planners and everybody else. High expectations (impossible of proof by example) in the minds of these agencies only succeed in leading the country to frustration, mutual recrimination, despondency and gloom. I submit that this is what has happened in our country. The national laboratories have been created under this atmosphere of "over-expectation" and I submit that the present controversy on the manner in which industrial research should be organised, is in no small measure due to this single factor.

3.0 Over-publicity to Research Results at an early and unproved stage is highly dangerous

My First Suggestion is, therefore, directed to those who are responsible for formulating executive policies and detailed steps for implementation. *They must put a stop to publicising the economic role of the industrial researcher* in generalised terms. They must also refrain from publicising their activity in the exploratory or research phases of their work. The economic impact of applied research in tangible form is seen usua-

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chily after 10-20 years in an advanced country and in a developing country like India, this impact may be felt after 20-50 years. Undue publicity of the role and work of research laboratories does more harm to the research scientists and to the cause of science and technology in the country.

4.0 Vociferousness of the Industrial Researcher

It is well-known that policy decisions require experience and depth and maturity. Generally the older people and those who are engaged at the ministerial level in Government and at the entrepreneurial level in industrial establishments (both public and private sectors) are in a better position to set balanced and feasible policies in regard to the role of the scientists and the technologists towards economic and utilitarian ends. Even at these levels, there is lack of experience in matters of industrial experience and one has to be very cautious and careful in setting policies and taking far-reaching executive measures. From this point of view, I am totally opposed to the tendency towards vociferousness of the young industrial researcher engaged in various laboratories. It is interesting to note that controversies in the field of industrial research are, by and large, limited to the national laboratories of the CSIR. Those scientists and technologists who are engaged in medical, biological or agricultural research or those scientists and technologists who are working in industrial research laboratories managed by private or public sector industries or those engaged in the atomic energy establishment etc. seem to be less vociferous and less bothered about such matters as import substitution, self-reliance etc.

Therefore, My Second Suggestion is that generalised questions of national importance such as "need and extent of science planning" or setting fiscal and other policies for "self-reliance in science and technology" etc., should be separated from the particular problems with which the CSIR, as an organisation, may be facing. To take a decision at a national level against the background of a "problem child" as it were, would not be appropriate.

5.0 Science Planning

This brings me to the question of "science planning" the oft repeated slogan. I do not know of any word which is more vaguely used than this. Does this mean planning of science education ? Does this mean planning of academic research in universities and other centres of academic leaning? Or does it mean planning of science in various ministries. Or is it related to planning in the Planning Commission ? Does it mean planning of science in the CSIR Head Office or does it mean planning of work in individual national or industrial laboratories in the public and private sectors?

To pose a generalised question as to whether "Planning of Science" is required, is imprudent and meaningless. *The question of a central planning authority for science to set broad patterns of science development is related not to our desire to do it but to our capacity to do it.* This capacity is determined by the availability of experienced men with vision and maturity and a proven record of successful work. In an underdeveloped vast and complicated multistate multilingual and mixed and essentially democratic country like India the question of science planning is much more difficult and complicated than the national planning or industrial planning in which the Planning Commission has now been engaged.

If under the present background one is thinking in terms of starting a national ally after 10-20 years in an advanced country and in a developing country like India, this impact may be felt after 20-50 years. Undue publicity of the role and work of research laboratories does more harm to the research scientists and to the cause of science and technology in the country.

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If under the present background one is thinking in terms of starting a national science planning organisation; I am afraid that we cannot expect any better results than what has been achieved by the starting of 30 odd national laboratories for performing industrial research.

6.0 How best can Science and Technology Feed our Industry

Here again it is necessary that every time an industrial unit is built, use is made of science and technology. There is no question about this. The point which is relevant is, does Indian science and technology feed Indian industry ? What steps must we take for such a thing to happen? What is the extent of success possible? The subject is too vast but I would venture to make a few suggestions. *At the outset I wish to point out that the responsibility of using Indian Science and Technology is that of the customer—in this case the entrepreneurs and builders of industry in the public and private sectors—and not that of the scientists.* The decisions in this regard must be taken on the basis of technical, financial and entrepreneurial and market feasibility and not merely on the basis of our desires. The suggestions I am making below are based on 25 years of continuous work in the field of industrial research and I hope that these would be of use and interest to our policy makers.

(i) *First and Foremost*, we must understand that research forms only 1/20th to 1/50th part of the total effort required to start a new industrial undertaking. The projects chosen for this purpose must be conceived at the entrepreneurial and rather than at the research laboratory end.

(ii) *Secondly*, in most cases the cost of foreign know-how is neglegible in comparison with the total cost. It is, therefore, better to buy this know-how than generate the same through local research effort. However, it is very prudent to establish a research unit simultaneously. Then one is in a better position to undertake meaningful research to keep abreast of world-trends and to compete in quality at an international level. The returns from such an approach are likely to be far greater than the one based on mere self-help, based on second rate or third rate repetitive research.

This does not mean that laboratories not formally linked with industry or not managed directly by them, are not required. There is a lot of first rate applied research which they can undertake. There are hundreds and hundreds of useful research projects in which work can be done. But success in such effort will only come if the new invention is better than other known inventions in the field or essentially claims better economy than is normally available to the industry. The present practice of choosing projects in which mere know-how collection rather than substantial research contribution is involved, has proved to be unfruitful—even wasteful.

(iii) *Thirdly*, once these objectives are clear, one should consider Indian know-how as a commodity for sale. Japan, West Germany, USA, USSR, Hungary, Czechoslovakia—all of these countries today both sell as well as buy know-how. It is the balance of payment for know-how rather than "self reliance" or "saving of foreign exchange" that should be the keynote of our policy.

(iv) *Fourthly*, since the development expense involved in using results of research require huge finances and long time, it would facilitate matters if the results of research claim a basic originality of a high order. This, however, is in itself not enough. The project must be technically, financially and marketwise feasible. More than one party is involved in this and as a senior scientist of the country mentioned the other day, it would be most unwise for the scientists and technologists to be at dagger's drawn with their potential customers—I mean the industrialists and the government officials in the various ministries. It is necessary, therefore, to make a thorough feasibility study and to ensure the enthusiastic participation of the user in all development work. If the industry put in 50% of development finance so far the better. It is also useful to associate a consulting engineering firm during the development stage on agreed and mutually acceptable terms.

(v) *Finally*, we must make sure that we do not spread our butter too thin. We must choose projects or fields of high scientific and technological impact rather than mere economic impact; these again should be not in all and sundry fields but only in a few chosen fields.

Science based industries like the chemical and the electronic industries give quicker and better returns in industrial research. When such industries require low capital outlay or are labour intensive they are of particular interest to a country like India. Conversely, returns from research for raw material based or capital intensive industries are very much more difficult and in such cases men of the highest calibre and competence are required and the aims for originality and creativity must be of a high order.

7.0 Conclusion

In conclusion it can be stated that national policies on science and technology need to be formulated with wisdom and on pragmatic considerations. Broad platitudinous generalisations only help to create over-expectations and consequent frustrations. It would be better for the Indian Scientist and Technologist to bother more about the quality and excellence of his work rather than engage himself in futile controversies of a social and political nature. We have too much of promotion and propaganda but too little of quality work.

Science Round Table – Some Points

A. R. VERMA*

The question, to what extent the slogan of "Self Reliance" in the field of technology, can be made meaningful and effective, is allied to the question of "the limits within which foreign collaboration should be encouraged." These questions have to be approached purely pragmatically. Taking the second one first, the decision on whether foreign collaboration is necessary or not, should be dictated by :

(a) the importance of the particular industry in the overall national development, based on priorities of the items to be produced.

(b) How quickly we want to produce the end products.

(c) The state of the technology available in the country and the type of industry.

For example, there are foundries for making large size castings, fabrications of large size pressure vessels and structures, and certain types of heavy electrical equipment, where the technology has more or less been stabilised for many years and there does not appear to be any immediate possibility of a major change in technology.

There are a second group of industries such as Nuclear Engineering and Electronics where, the change of science & technology is so rapid that one has to have a different approach altogether, namely if the country is to advance, we should start at a level at which the technology has already reached in developed countries. The same applies to the Aircraft Industry.

In either case, as regards foreign collaboration we should confine ourselves, as far as possible, to setting up one economically viable unit well chosen, with the definite stipulation with the collaborators that *they should permit us to copy their plant* apart from training our men. Preferably our scientists and engineers should be associated with the fabrication of the plant itself at the factory of the collaborator in his own country, and should even be associated at the design stage. By laying down this primary condition, even if the financial terms of a particular collaborator are stiffer, we should consider it worthwhile.

Now let me come to the first part of the question, namely the extent of "Self-reliance" that can be effectively achieved. *The first step that should be taken is that any additional capacity of plant and machinery for producing the same product for which the know-how has been imported, must be fabricated in the country itself.* In the past 20 years, we have established sufficient expertise in all the technological fields, whether it is heavy industry, light industry, Electronics or Nuclear Engineering. So there is absolutely no reason, whatsoever, to enter into further collaborative agreements with entrepreneurs and importing machinery and equipment from them.

The plea will always be raised that this is absolutely essential in order to introduce

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certain amount of competition, and that the technology which is offered by another firm, will be different from what we already have. This argument is not valid. If there are any differences in processing, those modifications can certainly be incorporated in the equipment we build here. Our young men in all fields of science and technology have enough background and enthusiasm provided they are given an opportunity.

The following basic conditions may be laid down in any new collaborative agreement that we are likely to enter into:

(a) When a foreign collaboration agreement is signed, the terms must stipulate that Indian scientists and engineers get training in the collaborator's organisation.

(b) A national Institution which has facilities in equipment and personnel that correspond to the R & D labs. of the collaborator, must be chosen and assigned the task of working in close association with the Indian entrepreneur and his collaborator.

(i) their main object will be to undertake development work, either sponsored or otherwise, to utilise indigenous materials and find suitable substitutes of the required specifications.

(ii) Chosen scientists/engineers of the concerned institution who are to be associated with the project must be seconded to the firm and given free access to all the process know-how.

(iii) In order to ensure secrecy to protect the interests of the firm they should be asked to sign a suitable bond

(iv) In order to do development work at the designated National Laboratory or Institution a cell may be created where the scientists/engineers of the factory and the seconded scientists work together to solve the problem.

(v) From this stage the National Laboratory scientists should undertake intensive work to develop new products and techniques starting from the technology already available at the factory of the Indian firm/collaborator.

To give a specific instance to illustrate the validity of the above contention, it is known to all in this assembly, that the production of Electronic equipment and components which will go into the equipment, has to be given the highest priority. This has also been the view of the late Dr. Bhabha as spelled out in his report. Recently the Electronics Committee in trying to implement the Bhabha Committee recommendations decided, rightly, that in order to have a really stable and broad based electronic industry, components and the raw materials that go into the making of components, have to be produced on a very large scale. Based on this decision, a circular was issued to number of entrepreneurs inviting them to submit their proposals for production of components on a large scale.

One of the items is the transistor, which is now being produced by 3 firms, one in the public sector and two in the private sector. The total quantity that is produced is roughly about 6 million of which 4 million is produced in the public sector. All the three firms have negotiated with 3 different foreign parties and have established manufacture using the most uptodate technology for large scale production of transistors.

The Electronics Committee, however, felt that the requirements of the country in the coming few years, will be much more than 6 million. In fact it is expected to be of the order of about 50 million and so additional capacity has to be lincensed and new entrepreneurs should be invited to take up the production of this item.

Now this can be done in two ways (i) allow new entrepreneurs to enter into fresh foreign collaboration agreements or (ii) duplicate the processes already existing under the imported know-how. To give an answer to this, it must be borne in mind that the transistor production is capital intensive, particularly by way of foreign exchange, and for setting up production of 10 million transistors we require foreign exchange to the tune of Rs. 1 crore. So in order to set up production of 50 million transistors Rs. 5 crores of foreign exchange will be required. The technology of transistor production between the various firms with whom we may collaborate, is more or less the same except in certain minor modifications in processing techniques. The type of equipment, which they will require for mass production, will be the same as the one that BEL has got, or is expected to get, for their silicon transistor project.

Here is an instance where we have at least one factory in the public sector which is producing transistors on a continuous mass production scale on the most uptodate technology available, and their products have received universal acceptance. Therefore second alternative is the obvious answer.

Here is a golden opportunity where we can fruitfully insist on the collaborating firm, that we should be permitted to copy the production equipment. A small factory set up with a few experts in mechanical, electrical and electronics field or the Electronic Corporation of India (a factory which is coming up in Hyderabad for various types of instruments and equipment including nuclear instruments) should be able to copy the equipment. The possibility of using one of the electronics factories under the Hindustan Aeronautics Ltd. can also be investigated. If there are any copyrights or any patented device, a fee can be paid to the firm and with their concurrence, we can copy them.

Surely the total investment required for producing this 5 crore worth of equipment will not be anywhere near it. What is more, an opportunity will be given to our young scientists, engineers and technicians to use their skill in making the equipment.

This would certainly help in generating the second generation of equipment and further advancement in technology.

Some of you may be aware that transistor as a discrete device, is already on its way out; there are solid state devices such as the integrated and thin film circuits. The technology is similar in many respects to that followed in the transistor technology.

The organisation that is to fabricate equipment will be able to design and improve on the equipment to produce that required for mass production of the integrated and thin film circuits.

Generally an argument is advanced that because of the Secrecy Act no collaborator will agree to allow any of our scientists to work in their factory or permit us to copy. In one specific instance where NPL had

Dear Member,

The current issue of Vijnan Karmee in your hands brings to you detailed information on the Round Table of Scientists and Technologists invited by the Prime Minister on September 7-8, 1967. The volume of the issue contains 80 pages and has involved considerable extra expenditure which cannot be met from the meagre resources of the Association. This issue has been priced at Rs. 2/- per copy. I hope you will cooperate by giving a contribution of Re. 1.00 to meet the additional cost of the Journal. The Branch Secretaries are being requested to collect this amount from you.

Thanking you for your contribution and cooperation.

Yours faithfully,

Baldev Singh

(Baldev Singh)
Editor, Vijnan Karmee.

preliminary discussions with an Internationally reputed firm in the Electronics field, this question was discussed and the minutes as recorded and accepted proves the fallacy of the argument.

In conclusion, I would like to reiterate that

(1) for a few years to come our Research and Development should be primarily copying; copying intelligently not only the outside finish or shape of a product, but to study the details of every part and its significance in the smooth functioning of the product.

(2) Collaborative agreements when entered into, should make this an essential condition.

(3) Any additional capacity of plant and machinery for producing the same product for which know-how has been imported, must be fabricated in the country itself.

Strategy for Economic Advancement Through Research & Development in India

Amarjit Singh*

Implementation of scientific policy resolution

Although the Scientific Policy Resolution was in itself clear, its implementation has not been as full as might be hoped for. Some of the inadequacies are analysed in the following and remedies suggested.

Achievement of Speedy Results

Research is a highly time-dominated activity. There exists also a so-called "Threshold of investment".† In other words so long as the investment and the associated rate of progress are below a certain threshold, concrete economic benefits tend to be small. Slow administrative procedures automatically raise the threshold of effective investment, and are threfore wasteful in a very real sense, particularly in the case of research.

One way to get around this is to adopt a technique often used with success abroad. At the time of sanction of a project, all the needs in terms of men, materials (in our country these would include foreign exchange, import licences, etc.) are reviewed and approved. But once approved, the person-in-charge is able to operate the sanctions speedily and without much reference back & forth to other authorities.

Development and Utilization of Indigenous Know-how

There are many built-in-incentives for foreign collaboration in an industry that is not research-oriented.

Thus foreign collaboration may offer them turn-key jobs and may make minimum of demands on creative effort, either in design, production or even marketing.

On the other hand, development of indigenous know-how would demand more imaginative effort and teamwork. But for the country it results in large savings in foreign exchange and in building a firm base for further development.

The article in Economic Review quoted already, clearly brings out the intimate connection between the balance of payments position, and encouraging know-how development within the country vis-a-vis buying it from abroad.

In the larger interest of the nation, it is better that counter balancing incentives should be built into the development and utilization of indigenous expertise. It is, therefore, desirable that (a) where indigenous know-how has been developed already, it should be encouraged; (b) large projects for which know-how may not be available in its entirety, may be broken into smaller tasks: out of these a project team

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* Director, Central Electronics Engg. Research Instt., Pilani.

† Economic Review, Nat. Inst. of Economic and Social Research, London, Number 34, Nov. 1965, p.69.

may sift what is possible within the country at one or more institutions and what requires foreign assistance; (c) this sifting may be done as soon as requirements are finalized so that research teams may get the necessary lead-time to complete their assignment(s); (d) if foreign collaboration is sought, the country should be able to earn back the larger investment in foreign exchange through exports. An adequate quantum of export should be made obligatory in such cases.*

Planning for Scientific Research

Project-teams should first lay down the specifications of the product(s) required, and then as mentioned above should proceed to break up the total work into smaller tasks. The same project team should pilot it through various stages and sponsor projects with different participating organizations. In this way, all the funds that they spend would be utilized towards the fulfilment of a clearly specified objective.

Liaison Between Users' Research Organizations and Industry

It is necessary that the machinery for liaison should be strengthened in the research organizations on the one hand and users, Govt. ministries and industry on the other. The Third Reviewing Committee of the CSIR had recommended that each of the Ministries must have a cell which is specifically charged with the task of exploring ways of developing indigenous expertise, and using the available expertise for specific tasks.** Such cells could be like the Finance cells representing the Ministry of Finance in different Ministries or autonomous organizations. These could be coordinated by the proposed Ministry for Technology.

In industry, effective liaison with research organizations can be developed if they have their own cells for design, development and for day to day tasks of production engineering. Tax-incentives for this purpose are a step in the right direction.

A further mechanism that can help in this liaison would be deputation of staff from one type of organization to another for limited periods on specific tasks.

Priorities

In settling priorities, the following principles can be kept in view—(a) for engineering research, those projects would have higher priority where the savings can be large either by virtue of high cost(s) of the individual product or because of the large numbers required of a given product; (b) for applied research or exploratory development higher priority would be given to projects where a break-through in technology is seen; (c) for basic research, priority will have to be given to areas where new vistas of knowledge are seen to be opening up.

Here, it is well to emphasize the fact that true basic research or even exploratory development has to be at world frontiers.

Concluding Remarks

This brings us back to the point made in the beginning. India can reach the stage of a self-generating economy only if a large proportion of technological innovation and change can be generated on a continuous basis by harnessing Indian talent. To do this in a competitive way, we cannot but use the methodology and administrative procedures adopted abroad. India has no time to try and prove that modern sciences and technology can be grown on indigenous soil with out-moded procedures and attitudes. The margin of error has become too low already.

* Recommendations of Study Group of the "Conference on Management Tasks in the Fourth Plan" on 'Increasing Productivity Through Promotion and Application of Scientific Researeh & Development' (Planning Commission 1966).

** Report of the Third Reviewing Committee of the CSIR, p. 86.

Research Activities in the Universities

H. S. Hans*

A large number of young brilliant scientists from the Universities are abroad. According to one school of thought, it does us no harm if they stay away at least for sometime. I like to raise my humble voice against such thinking. I strongly feel that they should be persuaded to come back and join our various Universities and colleges. The plea that we do not have enough research facilities particularly in the specialised branches in which these scientists will be trained, appears to me to be untenable. A scientist is trained to use his knowledge and training to the problems which are useful to the society and in the general field in which he has got the training. He need not follow a straight line course for his research only with a view to either publish a large number of papers or to advance knowledge in the minimum area of his training. He should be able to fit himself to the requirements of the nation and if this requires a change in his over-all plans of research, this should not be avoided. These scientists, of course, should be paid enough money. But for the research plans they should fit themselves with the conditions of the country's needs. The institution of 'research Pool officers' has not proved useful because of their being temporary. To avoid this, quite a few permanent jobs should be created in the Universities and they should primarily be meant for research. The money spent on the Universities in this way will be well rewarded, not only in research but also in teaching.

(ii) The Universities should be encouraged to form schools of research instead of individual efforts though they also should be welcomed wherever they exist. As a matter of fact, I believe that the schools of research might involve sufficient interaction with the neighbouring disciplines so that slowly the individual research workers may automatically be absorbed in one of the schools of research.

(iii) The University research workers, by their very circumstances, have to devote a large part of their time to 'pure research'. It should not be expected from them, in general, to devote their time mainly to applied research if this is not their main discipline. On the other hand, I believe that even a pure research worker in a University specially when he is an experimentalist, should devote a good part of his time to the development of specilised instruments which are directly useful to his subject. Such instruments may eventually be standardized and put in the market through some agencies.

(iv) While it may not be possible to allocate a large amount of foreign exchange to the Universities, they should be given about 20 per cent of their funds in terms of foreign exchange.

Lastly I may like to make a general remark : While there have been various drawbacks in our scientific policies, the most important of them according to me are :

(a) More emphasis on individual achievement in a very narrow sense

(*Contd. on page 49*)

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Organisational Initiatives to Sharpen the Contribution of Science and Technology to National Development

Ashok Parthasarthi*

1. The evolution and implementation of any Science** Policy involves two complementary aspects. The first concerns the resources allocated, institutions built and programmes started, to develop basic, applied and adaptive research and development in the country. We shall designate this as the "policy *for* Science" aspect of a total national Science policy. Some of the more detailed elements of such a policy would be the strategy of resource allocation to various fields of research in both universities and research laboratories, the general directions of qualitative and quantitative growth of Scientific manpower, the dissemination of Scientific concepts and information among the general population. In developing countries there is, in addition, the question of the social and professional status of scientists and technologists.

2. The second aspect may be designated "Science *in* policy" and deals with the contribution of scientific and technological expertise to other policy problems in the area of defence, agriculture, industry, public health etc. which have a high content of science and technology. Until recently this component was a relatively small part of our total scientific effort but there are adequate indication of its very considerable growth potential.

3. Clearly, such a break-down of the field of Science Policy is neither unique nor devoid of redundances. Its chief merit is that it has been found empirically to be a useful working break-down in other countries. Thus, when attempting to translate the requirements of each of these components into organisational terms a compromise has to be struck between the degrees of distinctiveness and overlap.

4. The Present Position Regarding the Top Direction of Science Policy in India

4.1 A central problem in rationalising the existing advisory machinery available to Government on science and technology, is the interaction between the many bodies concerned with making policy evaluations and recommendations, as regards budgetary allocations, manpower needs and overall organisational requirements. These range from such groups as the Research Survey and Planning Organisation (RSPO) in the Council of Scientific and Industrial Research (CSIR) and somewhat similar groups of looser structure in the Department of Atomic Energy (DAE), which have an Agency frame of reference, to the Scientific Advisory Committee of the Cabinet (SACC) and the Scientific Research Division

* Department of Atomic Energy

** In this note, Science will be used to refer to science *and* technology.

of the Planning Commission (SRD/PC), which are concerned with problems of national scope.

4.2 The need to clearly identify, in particular, the respective roles of SACC and SRD/PC is of special importance, in view of there having been considerable uncertainty on this count, in the past. Moreover, the tendency towards overlapping and duplicative effort between these bodies is likely to increase in the future, as a result of two recent developments.

(a) the reorganisation of the Planning Commission into a completely advisory body,

(b) the steadily deepening involvement of SACC with a wider range of science policy problems.

4.3 Given the existence of these two groups how could a complementary division of labour be worked out? From a consideration of the fact that in terms of quality and range of scientific expertise, SACC is a far more competent body than the SRD/PC, it would appear that the former should be given a substantially expanded role in planning and policymaking in regard to the total content of the nation's scientific effort. At the same time because national outlays on scientific research and development will continue to be made within the framework of total Plan allocations, and since such crucial aspects of research, as manpower planning will come under the purview of the Planning Commission, the SRD/PC should be in a position to play a useful role. The following reorganisations are suggested with a view to developing the necessary complementarity.

5. An "Activation Plan" for SACC

5.1. There is a widespread feeling amongst Indian scientists and technologists, that the Scientific Community (such as it is) is being by-passed in decision making on agricultural, industrial, research and educational policy. This feeling is most acute among, what might be called the "middle-level" scientific leadership—heads of research laboratories and universities departments and divisional heads of large research organisations within the Government. By and large this group has a heightened sense of social and psychological identity of its own, largely through study, work or travel abroad. Its members are at the same time, convinced of the relevance and capacity of their skills to solve pressing national problems. As a result, not being called upon by Government to involve themselves with such problems, becomes a source of actute frustration. With the pressure to migrate a constant factor, the persistence of this frustration is a serious matter for our Scientific capabilities.

5.2 The most important arena for the interaction of the scientific community with Government, both as sellers of its skills and as buyers of its needs, is SACC. A decision to invest SACC with the role of the highest advisory body on Science within the Government, was taken in 1956. But this decision and its implementation have been given a level of visibility that do not appear to be fully justified even on grounds of security. Moreover the activities of SACC have been every intermittent over time. There is therefore urgent need, in view of the growth of the science-based sector in industry and agriculture and defence, that SACC be charged with adequate political and administrative authority to enable it to provide the Cabinet with a continuous and comprehensive overview of the nation's capabilities and problems in Science, and to translate its appreciation of them into specific policies and programmes. In its supreme advisory role to the Cabinet on matters of Science, SACC should undertake surveys, studies, and problem-solutions both on its own initiative and in response to specific directives from the Cabinet.

5.3 To be able to do this on a dynamic basis SACC should acquire a small permanent staff of science analysts (around 5-8) with professional backgrounds covering an adequate number of fields in the natural and social sciences and engineering. This staff could do most of the secretarial and analytical work on the enunciation of the committee's policies and programmes, and also liaise with various Government departments.

5.4 **Extensive adoption of Panel or Working Group System**

To undertake these tasks and to marshall the best expertise in the country SACC should develop the panel system as its mainstay. Since 1962, SACC has, of course, increasingly used the working groups as an organisational method of obtaining answers to specific technical problems, particularly in the area of defence. However, there is a great need to expand the activities of these working groups into the various non-defence sectors such as family planning, agriculture and food, science education, communication systems etc., where major "Science in Policy" issues are involved. A few standing panels could be set up to watch such major areas on a continuing basis while other panels could be set up to deal specifically with particular problems (e.g. current state of world technology and national capability in the area of grain storage), prepare reports on the "state of the art or discipline" (e.g. design and development capabilities in various industries), etc.

5.5 The urgency and the need to set up such a panel system on an extensive basis cannot be overemphasised. A highly deleterious feature of our organisational structure for research and education in Science, which has been well known for many years, is the alarming growth of a "Science bureaucrary" between the political decision maker and the practising scientist. This bureaucracy is composed moreover, of people with little understanding of either natural science and technology or of the role of the social sciences in increasing the productivity and utility of the former. Instead of fulfilling a mediatory role between "Science" and "Government" it has become an obstacle to communication. By investing SACC with the power to constitute panels of Scientists who are specialists in their respective problem-areas, "Government" will be able to establish a most necessary direct communication channel to "Science".

5.6 The system could thus fulfil the following functions:—

(i) Identify scientists and technologists, talented in their respective disciplines to tackle problems falling within such disciplines.

(ii) Identify scientists with a policy, planning and administrative orientation and thus develop a crucial resource for future scientific research in the country.

(iii) Provide an avenue for creative self-expression and productive involvement of the middle level scientists in industry, research laboratories and universities.

(iv) Provide a source of new blood for SACC, so that the Cabinet is in a position to have the benefit, over a period of time, of the best and widest range of scientific advice available.

5.7 As an excellent example of the value and efficiency of this panel system, we might consider a national programme for food production and agricultural development. Such a problem is a typical "systems" problem involving the interaction of such elements as, improvements in agricultural technology (e.g. design and development of cheap storage facilities using local materials and the working out of a location pattern which is the 'optimum' in relation to distribution patterns) agricultural science (e.g. new seed varieties) advances in food processing and development of dietary supplements and substitutes. Since the necessary expertise to tackle such a problem is widely scattered through many institutions, a standing panel of representatives of the leading research institutes and agricultural universities with necessary subsidiary panels to tackle specific problems would be an excellent method of organising our research and planning capabilities in the area. It is a matter of some regret that while the comprehensive study on World Food needs prepared by the Presidential Science Advisory Committee of the United States, should be the basis of increasing discussion of India's food and agricultural strategy, a similar panel has not been set up by SACC for the same purpose to tackle our own particular problems.

6. Institutional Structure for Science Administration within the Government

6.1 Science Budget

6.1.1 The proposal here concerns the mode of evolution of a Science Budget. From the point of view of the well recognised role of the Planning Commission in developing guidelines for national resource outlays as also the great importance of preventing the inter-agency interactions inevitable in a budgetary process from attenuating the efficacy of SACC (which is based largely on the principle of scientists being chosen as talented professionals and not necessarily as agency heads) it would be most appropriate if this function be wholly that of the SRD/PC—within the terms of reference of its advisory role. However to again give greater involvement to practising scientists in matters deeply concerning them, the following modification of the existing system may be considered.

6.1.2 An Inter-departmental Council for Science and Technology could be set up as a standing body. On this council, every governmental department having 'significant' scientific and technological interests would be represented by a science administrator. He would be either a social scientist trained in research administration or a natural scientist with research experience. The member of the Planning Commission in charge of Scientific Research would chair the Council. The Secretariat of the SRD/PC would serve as the staff of the Council. The Council would serve as the clearing house of all scientific and technological information and also as the coordinating arena where both the technical programmes and budgetary requirements of the various departments would be presented and integrated without duplication. The budgetary implications of various technical and scienfic programmes suggested by SACC and approved by the Cabinet would also be introduced at this stage. In this way the deliberation of the Council would culminate in the building-up of science Budgets both for the year and for the plan. They could then be forwarded to the Ministry of Finance for sanction.

6.2 Ministry of Science and Technology

In the constitutional and administrative setup in the country, a Ministry of Science and Technology does not appear at the present time to be capable of producing increases in efficiency, either in decision making or in execution. The main reason for this assessment is that such a ministry would have to function according to established organisational norms of government administrative departments. In an executive structure determined by the 'chain of command' principle, as British experience indicates, Science can make progress only *in spite* of the structure. Moreover the inter-ministerial conflict of interest so characteristic of the Cabinet process, would also be a major limitation. However there is need to rationalise the location of some of the major agencies in the various ministries. The most glaring case is that of the CSIR whose logical 'home' should be the Ministry of Industrial Development. With such a change at least the administrative impediments to closer collaboration with public sector industry could be removed.

7. Governmental Initiatives in the Creation of a Single National Professional Society for Science and Technology

7.1 If science and technology are to play their part as vigorous institutions in any society, it is essential that strong professional associations of scientists and technologists belonging to various disciplines develop and grow with energy. However, in a developing country like India where Science has the additional role of intellectual and cultural integration, the structure of the professional organisation of the scientific community is of particular importance. At present, there are 4 major scientific societies in the country—(1) The Indian Science Congress Association, Calcutta, (2) The National Academy of Sciences, Allahabad, (3) The India Academy of Sciences, Bangalore, and (4) The National Institute of Sciences, Delhi. The existence of so many 'national' scientific societies in a country with 40,000 research scientists and technologists leads to serious fragmentation of the total scientific community. The establishment of the National Academy of Sciences in the United States, the Academy of Sciences in the Soviet Union and more recently the Science Academy in Japan have contributed greatly to the development of a coherent and articulate scientific community in these countries. It is well-worth pointing out, in this connection, that the Academy of Sciences of the Soviet Union is fully Government body. Both the National Academy of Sciences as in the United States and the Science Academy in Japan are of a semi-governmental nature. This particular character of the latter two professional societies is an indication of the concern of the governments of these countries in having a single representative body of professional scientists outside Government.

7.2 It would, therefore, be most appropriate and very timely for Government to take a major initiative in this matter. This could be done by convening a meeting of the officials of the four leading scientific societies mentioned earlier to decide on their mode of integration into a single society of national scope which may be given some such name as "The Indian National Academy of Sciences" or "The National Academy of Science & Technology" etc. Once such details, as the headquarters of the association, the mode of affiliating of membership of existing societies, the new National Society etc. have been decided, a tentative date for the inauguration of the new society could be fixed and the Prime Minister could very valuably inaugurate it with appropriate publicity.

7.3 The formation of such a Society would also lead to a fruitful exchange of ideas and pooling of intellectual resources between it and an "activated SACC". The Society could, for example, develop rosters of its members on a discipline basis and such information could provide SACC with the pool of talent from which its panels might be formed. With careful planning, it should thus be possible to fulfil the requirements of the "policy for Science" and "Science in policy" aspects of a total national Science policy through the "National Academy" and the SRD/PC on the one hand and SACC on the other.

8. Initiatives on Scientific Manpower

8.1 In the last very few years, Government has decided to initiate major efforts to develop such critical science-based industries as Fertilisers, Electronics, Aeronautics, and Atomic Energy. These are industries where the quality and quantity of the available scientific, technological and managerial personnel and not capital or foreign exchange resources, is the key to success. The electronics industry alone, for example, has been assessed to require some 300,000 scientists, engineers and skilled workers by 1975. What is more, the whole future of these industries depends on the generation of powerful design and development groups, fully integrated with production plants on the one hand and research laboratories on the other. Such activities require the highest degree of originality and innovative skill. They thus give scope for that "edge of challenge", the lack of which, Indian scientists, especially those abroad, often complain.

8.2 It would be natural to expect, therefore, that the knowledge of a policy decision which would be instrumental in generating such immense employment opportunities, should have provided a boost to the sagging morale of India's Scientific manpower. However, it appears that, in fact, little impact has been made either on the component within the country or that which is currently abroad. There is thus an urgent need for government to give far better publicity both at home and abroad to the programmes envisaged for the growth of these science-based industries. The enormous opportunities for productive employment of *high level manpower* in particular should be emphasized. More specifically, government might announce within the next six months a comprehensive programme of incentives for scientists and technologists in research, teaching and public sector industry e.g. 10 to 15% increase in salaries together with improved social benefits in regard to health, education of children, foreign travel etc. As regards Indian Scientists abroad, the incentives might take the form of assurances to provide housing, health and educational facilities on their return and also relaxation of import restrictions on consumer goods. The building-up of a pool of competent and motivated scientists and engineers has a long gestation period. However, such a pool, as the development of Chinese capabilities, in nuclear science and technology indicates, is a major national resource and must be tapped, husbanded and expended as such.

9. Do We have the Political Will?

9.1 A basic problem facing Science in India today, is the need for it to become an activity fully internalised, in regard to goals, tasks and norms. Part of the effort to achieve such internalisation of the cultural thrust of research and innovation, must be made by Indian scientists and technologists. The will to create a scientific community as a distinct social group, with such operational norms as the evaluation of performance through the judgement of peer groups and a highly 'horizontal' internal decision-making machinery, must remain the objective of such efforts. But precisely because, the end product of this kind of operation will be a deeply self-conscious and articulate social group, there is an equal responsibility on the part of Government to safeguard the interests of the former and, at the same time, utilise its services.

9.2 It appears, that the respective responsibilities of Science and Government in developmental tasks, will become clearly identifiable, only when it is realised that something less than half (if that) of Science Policy-making is 'scientific' ! For example there is no 'scientific' way of deciding what percentage of its GNP, a country at a particular level of socio-economic development, should spend on scientific research and technological development, or to what extent the full potential of the results of indigenous research have been made use of in the attainment of community objectives.* Such questions can and must be answered only in terms of the societal goals and scale of priorities of the prevailing political order and *its appreciation of the contribution that Science can make in achieving these goals*. Thus all attempts to rationalise formal organisational structures for Science within and outside Government can be of value, in the last analysis, only to the extent to which adequate political resources can be committed in their support.

* See for example; P.N. Chowdhury and A. Rahman "Investment on Scientific Research and Development—A Sectoral Analysis", *Lok Udyog*, Vol. I No 3, May 1967, pp 67-74

(*Contd. from page* 42)

and less emphasis on the social usefulness of the research activities. This has led to aberration even in those of our activities where nation has spent a large amount of money. Somehow, a situation should be brought about by which the personal recognition of a scientist is very much tied to the social usefulness. A certain amount of urgency is required in giving this social meaning to our research.

(b) There has been too much clamour specially in our Universities to purchase, with foreign exchange, a lot of costly equipment which sometimes remains unused or is only partially used. Somehow I feel that more recognition should be given to those research workers who have developed indigenous equipment of some complexity rather than the man who has used a foreign imported equipment and has published a certain number of papers.

Round Table of Scientists and Technologists

A. N. Ghosh*

To remove poverty and make the nation affluent, science, technology and scientific methods of development are undoubtedly the best means available today.

The Scientific Policy Resolution enunciated by late Shri Jawaharlal Nehru and adopted in 1958 is adequate and comprehensive. However, in the light of the last 20 years' experience, there appears to be a need for giving much thought to the implementation and change of emphasis in this Resolution. Given below are some observations for consideration :

1. Laboratories--A large number of scientific laboratories have been established, but what has been often lacking is the proper communication between these laboratories and between them and the industry. It appears now to have been more or less accepted that the CSIR laboratories should concentrate on research work which is industry-oriented, and more attention should be given to enable the research results obtained in these laboratories, to be made effective in the industry, and fundamental research should be left to be done by the universities.

In order to make the research results in the national laboratories adaptable by the industry, it is felt that from the very beginning the likely user of the research results should become associated both financially and technically with every research project and all along the line of its development. This will have two advantages :

(a) Research would be more industry-oriented and not merely academic, and

(b) Industry would be in a position to appreciate the new lines of development, and also help in making the research more practical.

2. Top Scientists—Although the number of scientists has increased during the last 20 years, the number of high calibre scientists both in the industry and the universities cannot be considered to be adequate for the needs of the country. The main sources of the country's young scientists are the universities and the technical educational institutions. Teaching in these institutions has lately suffered because of the difficulty of attracting highly talented scientists and technicians to such educational jobs and continuously retaining them in the services because better opportunities become available to them in the industry and elsewhere. This lacuna is further aggravated by the flight of talent abroad. This flight is due to several causes :

(a) Not enough recognition for the scientist's talents (Unfortunately in India, a foreign scientist, even of a low calibre, gets more appreciation than an Indian scientist of really high calibre).

(b) Lack of proper amenities and environment including laboratory facilities for work.

(c) General lack of encouragement from superiors.

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3. Training—Training of technologists for the industry is also not adequate, particularly in the second and third levels. For example, although just at the present moment we have a large number of unemployed engineers of degree and post-graduate category, there is not enough of technical hands to man the shop-floors in the form of foremen, supervisors and operatives, with the result that qualified engineers are doing jobs much below their technical ability. The possible solution to this problem would be to make available more opportunities for training of the polytechnic type and also restricting the admission of students to the degree course in engineering.

4. Motivation and Incentives--In order to encourage creative talents and give full facility to scientific development, it is necessary to give the young scientist proper motivation and greater incentives than at present. In this connection, Section 1 of the report of the Planning Commission Subcommittee on Motivation, Training and Publicity (*see* Appendix A) is very relevant.

5. Academic Freedom—Much has been said about academic freedom which fosters individual initiative and discovery of new knowledge. It has, however, been noted with regret that even university laboratories are not free from interference in the individual initiative of juniors by senior colleagues or heads of departments. The atmosphere of academic freedom must be made the rule. However, freedom should not, in its turn, lead to complete breakdown of authority.

6. Publicity—In order to ensure that the benefits of research and scientific knowledge reach the people, there must be more contact between the research organization and the public at large. Although much work is done in the research laboratories in the scientific and agricultural sector, the public at large is usually completely ignorant about the work that has been done, and this ignorance is not conducive to better appreciation and effective acceptance of the research results in the country and, therefore, its utilization lags behind (*see* Section 3 of Appendix A).

7. Technical Administrators—It is unfortunate that scientists and technologists are not very effectively associated with the top administrative and policy-making bodies of the country although some scientists have been given top assignments. In general, it is found that scientists and technologists are under the administrative control of non-technical administrators. This results in technical plans for future development being hampered as authorities, both administrative and financial, are unable to appreciate and understand fully the technical implications and feasibility of the proposals which would lead to long term economic benefits.

8. Foreign Collaboration—Coming to the question of self-reliance in the field of technology, the point to be emphasized is for import of only such technology as is definitely not available in the country and is beyond the capabilities of Indian technologists because of recent developments abroad. Examples are not wanting where package deals for collaboration have included the importation of technology already well-established, and perhaps more developed in India than available at the foreign collaborator's level. For instance, many package deals contain civil engineering constructions of buildings, roads, factories, etc., including architectural designs imported into the country. Naturally, these civil engineering designs are based on experience of the country of the collaborator and have in many instances led to civil engineering designs not suited to this country. Further, such designs may require importation of basic materials like steel sections and other engineering components from abroad because of their not being according to the standards developed for such products in the country, namely the Indian standards. It is, therefore, imperative to screen the collaboration arrangements and insist on importation of only that technology and design which are definitely not available in the country, and cannot be substituted by indigenous technology and design.

There are many cases where collaboration agreements have been signed without due consideration being given to the basic materials for which standards are available in India and production of which is well established in the country. Further, collaboration projects in which there is to be any sizeable requirements of imported raw materials or components should generally not be approved.

Collaboration agreements usually contain clauses for Indian counterparts to be trained abroad in the country and organization of the collaborating authority. For such overseas trips, trainees should be sent to acquire only those technologies which are not available in this country. Similarly, experts from the collaborating country should be those who deal with subjects for which the Indian counterpart is not available. It is common knowledge that many experts have come to India to give advice on subjects on which Indians are much more knowledgeable and experienced. This action is not only wasteful in money, but also leads to frustration on the part of the Indian counterpart who in all respects remains more qualified than the expert. Just as it is important for India to send only properly qualified trainees abroad, the experts from abroad should also have the proper qualifications, and therefore it is necessary that the Indian counterparts should be satisfied that expert advice from abroad is necessary and the proposed foreign expert is the right man. Whenever a package deal is made, there should be an understanding that for every foreign expert who is engaged, there should be an Indian under-study to take over from him as soon as possible. This will naturally lead to the services of the foreign expert being required only for a limited period.

9. Conclusion—The organization and the policy regarding science and technology has been the subject matter of investigation of the Expert Group on Engineering Sciences of the Administrative Reforms Commission. This Committee is looking into the matter and its report will be made available very soon. It is hoped this report will receive careful consideration as it contains certain important recommendations regarding the reorganization of various scientific laboratories.

Appendix A

REPORT OF THE PLANNING COMMISSION SUBCOMMITTEE ON MOTIVATION, TRAINING AND PUBLICITY

INTRODUCTION

0.1 The Subcommittee on Motivation, Training and Publicity was appointed at a meeting called by the Planning Commission on "Guide-lines for economy in Construction Cost" held on 6 December, 1965 in Vigyan Bhavan, New Delhi. The Subcommittee consisted of the following :

Dr. Lal C. Verman, Director General, Indian Standards Institution (Convener);

Shri M.V. Desai, Adviser, Ministry of Information and Broadcasting,

Shri C.B. Patel, Director, National Buildings Organization,

Shri S.G. Pendse, Director of Training, Directorate General of Labour and Employment,

Shri G.K. Vij, Chief Engineer, Central Water & Power Commission.

0.2 The terms of reference of the Subcommittee were as follows :

The Committee may suggest :

(i) motivation or incentives to be given to engineers and artisans as a measure of economy;

(ii) training of artisans to save waste and improve quality of work;

(iii) publicity of good engineering works where economy is achieved.

It was further emphasized while constituting the Subcommittee that the report on the scope should be action-oriented.

0.3 The committee held three meetings between the end of January and the middle of March during which all matters coming under the terms of reference were discussed, keeping in view the objective of achieving optimum utilisation of the vast outlay envisaged in construction projects in the fourth Five Year Plan. In these discussions, the committee was also assisted by the participation of Maj Gen Harkirat Singh, Adviser (Construction) and Shri A.N. Malhotra, Director (Construction), Planning Commission.

0.4 In this Report only the recommendations of the committee are given briefly without the full background of discussions held, the object being to pin-point avenues of action which is urgently called for. The committee feels that these recommendations should be earnestly and speedily implemented if maximum benefit is to be derived.

1. Motivation and Incentives

1.0 The committee recognized that the questions of motivation and incentives were largely concerned with the psychological and human factors which have to be taken into account to get the best out of the technical personnel engaged in construction projects—large or small. Incentives present an appropriate device through which motivation may be provided, but they cannnot by themselves meet the present-day challenge where many complex human problems are involved, such as those concerned with the creation of proper climate for everyone concerned to put out his best effort, which means, among other things, that:

(i) everyone feels an important member of a group engaged in useful national activity;

(ii) people under whom he is working are, to his mind, capable and efficient leaders, towards whom he would naturally feel a sense of respect;

(iii) his work is being appreciated and in exceptional cases even being materially rewarded; and

(iv) any delay or failure to win recognition is most likely an indication that he should strive harder and not to feel frustrated.

These and many other human factors enter into creating the right climate. The committee's recommendations therefore could only be limited to such concrete steps as would require administrative action, but in order to produce the right climate many other things will have to be done, including very careful selection or even training of professional leaders to ensure that he possesses the skill required to deal with human material.

1.1 The committee noted that in the present system of working of the public services, the supremacy of the administrative secretariats over the technical personnel worked as a disincentive for taking initiative by the latter. It recommends therefore that the present system of public administration should be appropriately modified so that the control of all technical departments from the lowest levels right up to the top level should be entirely in technical hands both in the States as well as at the Centre. (Prime Minister, Shrimati Indira Gandhi in a recent speech has endorsed a similar course of action).

1.2 It is further recommended that the pay scales of the engineering services and other perquisites of office should in no case be inferior to those of the corresponding administrative services.

1.3 If an engineer during his employment makes an extra effort to acquire additional qualifications or makes an outstanding contribution to achieve economy in construction, he should be appropriately rewarded by the department or the project with which he is concerned. Furthermore, whenever an engineer or group of engineers show greater aptitudes or higher efficiency they should be suitably rewarded by the department or the project concerned.

1.3.1 The committee recommends that the heads of various departments in charge of executing projects should be recognized as competent authority to recognise the contributions made by members of their staff towards achieving economy and efficiency and to award incentives to deserving individuals and teams of co-workers in their departments. The awards may take the form of advance increments, out of turn promotions, accelerated promotions, cash awards, certificates of merit, etc.

1.4 In addition, the committee feels that there should be incentives constituted at the national level and recommends as follows:

(i) National awards numbering not less than ten should be instituted by the Planning Commission to reward individuals or groups for outstanding achievements in construction economy.

(ii) The awards should take the form of lump sum payments, ranging from Rs. 10,000.00 to Rs. 50,000.00 for each significant achievement.

(iii) The Planning Commission should invite proposals every year for the awards from all over India.

(iv) A board of judges appointed by the Planning Commission should select the recipients of the awards.

(v) Awards should be given only in deserving cases and not as a matter of course.

1.5 The committee felt it necessary to draw the attention of the appropriate authorities to the undesirability of the extreme degree of vigilance exercised in recent years by the Special Police Establishment, the Department of Technical Examiner, the Vigilance Departments and other similar agencies. While such vigilance may have succeeded in putting down corruption to some extent, it was at the same time acting as a serious disincentive to sincere workers, resulting in the loss of initiative even at senior levels. The committee therefore recommends that the following steps be taken which would be an effective alternative to present methods for putting down corruption and encouraging increase of efficiency :

(a) Place the whole responsibility for the proper and efficient working of the departments and projects on their respective heads, giving them full powers of staff under them;

(b) Leave it to the heads themselves to deal as a rule with all cases of corruption or other malpractices within the department. Outside agencies concerned with vigilance should remain at the disposal of the heads for conducting independent investigations if the head of the concerned department or project were to ask for such help.

(c) In relation to the departmental head himself, the outside agencies should have the responsibility to maintain close vigilance.

(d) The quality control mechanism within the construction departments should be strengthened by establishing quality control units responsible directly to the head himself.

2. Training

2.0 Until the recent past, most skills in India had been passed down from father to son, as indeed was the case in most other parts of the world until a few additional decades ago. With the development of increased demand for skilled workers, and evolution of new technologies requiring newer and more sophiscated skills, coupled with the urge to boost productivity, systematic training of workers has acquired a degree

	Trade	*No. of seats sanctioned*	*Seats introduced*	*Percentage introduced*
1.	Building Constructor*	224	176	88
2.	Carpenter	7 290	6 288	86
3.	Blacksmith	5 468	4 688	86
4.	Plumber	1 248	1 040	83
5.	Sheet Metal Worker	4 288	3 632	85
6.	Welder (Gas & Electric)	8 188	7 640	93
7.	Wireman	8 528	7 656	90
8.	Electrician	13 032	12 048	92
		48 266	43 168	89

* Includes the trades of bricklayer, stonelayer, concreter, plasterer and floor layer.

of importance in modern economies, which India has had to recognize in early stages of planning. With the increased pace of development, training of skilled workers in India will have to be given added attention commensurate with our future needs.

2.0.1 In this context the committee noted that out of the 30 engineering and 22 non-engineering trades under the Directorate General of Employment of the Ministry of Labour and Employment, training is imparted at present in 8 trades pertaining to the construction industry and the capacities created in these trades up to the end of Third 5-Year Plan, were as given in Table at the bottom of page 55.

The period of training at present is 18 months for all trades but it is proposed to change this in the Fourth 5-Year Plan, when the period will be reduced to 12 months for some trades and increased to 24 months for others. Since economy in building construction is now to be given high priority the committee recommends that the lines in which training may be directly given should be as indicated in the following paragraphs.

2.1 The following may be considered as essential construction trades:

Bricklayer	Riveter
Concreter	Plumber
Stonemason	Painter
Plasterer	Decorator
Floor-layer	*Welder
Blacksmith (reinforced concrete)	*Carpenter (building and furniture)
Steel fabricator	*Wireman
Fitter (structural)	*Draftsman

*Trainees from these trades are liable to migrate to industries other than construction.

2.2 The Department of Labour and Employment should continually keep under review the requirements of the building construction trades in the country which in the past had not been given the importance they deserved. In the light of the present needs of the country, the existing facilities in respect of these trades should be considerably expanded.

2.2.1 In this connection, particular attention of the committee was drawn to the possibility of welding becoming more commonly used in construction as a result of implementation of Indian Standards on steel economy which is being pushed at a forced pace by the Ministry of Steel. The demand for qualified welders would consequently increase considerably. The existing capacity for training welders in India as seen from table mentioned in 2.0.1 is of the order of about 7,600 a year against a sanctioned capacity for 8,200. On this basis, however, of the planned production of steel plates, sheets, strips, structural steel, etc. it has been estimated that the requirement of additional welders during the fourth plan period would be of the order of about 80,000 which should call for an addition of 16,000 welders per year. It would be necessary, therefore, that the present plans for training welders would have to be considerably expanded to a level well above 16, 000 per year so as to always have an adequate number available to active employment.

2.2.2 For other trades, similar estimates may have to be made and adjusted from time to time. A measure of flexibility, therefore, would be highly advisable in creating and expanding facilities for training.

2.3 An amount of specialization in training to a degree greater than now exists was called for. It should be examined as to what extent this could be done, especially in trades where already a good deal of specialization existed in field practice but not so much in training, for example, blacksmiths (reinforced concrete), plasterers, floor-layers, etc. Such specialization would be conducive to improving the quality and reducing the period of training.

2.4 In some of these trades such as brick-layer, mason, plumber, etc. the training period could also be considerably reduced. In order, however, to achieve this, it would be necessary to introduce manual dexterity test, among others for selecting trainees for admission.

2.5 In addition to the training centres organized by the Ministry of Labour, training of tradesmen should be simultaneously attempted as a necessary part of all large projects where expenditure on training could be absorbed in the project outlay itself. Some experience on these lines was available in Bhakra Nangal and Farakka projects, which could be used as a model to other projects.

2.6 It was particularly desirable that permanent public works departments at the Centre and in the States should also give serious attention to training on these lines. This may require some additional expenditure, but it would more than pay for itself by yielding higher quality, efficiency and economy.

2.7 In all official agencies, it must be a recognized practice that if a worker in particular skills, such as carpentry, masonry etc. has a certificate from a training institute, he should be given a premium in wages. In the case of wiremen and plumbers, however, it is considered essential to actually ban all workers not having a certificate of any kind. To achieve this, the existing inspection procedure in these trades should be tightened.

2.7.1 Those workers who were already skilled should be provided facilities for obtaining a trade certificate without having to undergo a formal course of training, and without undue formalities.

2.7.2 The responsibility for recognition of the competence of an Institution to issue such certificates should be vested in a central body, such as the Labour Ministry.

3. PUBLICITY

3.0 With regard to publicity the committee emphasized that wide publicity was essential for the purpose of promoting the achievement of significant economies. It was necesssry to bring to the attention of engineers at large the important technical information and data having a bearing on construction economy, of which a large volume was already available in the country as a result of the past researches and actual construction experience. The publicity given to such information is intended to create awareness among engineers and others engaged in construction projects about the need and possibilities for economy and also to enable them to profit from the knowledge of other's experience. The Committee felt that the value of publicity in creating such consciousness was not at present being adequately appreciated in authoritative quarters and this attitude will have to undergo a significant change if substantial results are to be achieved. In order to meet the present situation, the following recommendations are made:

3.1 The National Buildings Organization, the Indian Standards Institution, the Central Water and Power Commission, the Central Board of Irrigation and Power, the Indian Roads Congress and other similar organizations should extend their facilities to serve as clearing houses for technical information in their respective fields. They should not only be responsible for collecting and making available such information to engineers on demand, but should themselves publicise it through all the channels open to them, such as their own publications, the "Yojana" of the Planning Commission, etc.

3.2 All large engineering projects should themselves publish detailed reports on all matters connected with the achievement of efficiency and economy obtained during their construction operations, which could be useful to engineers engaged elsewhere in similar activity. In this connection it was emphasized that the responsibility for writing of such reports should not be left diffused but should be squarely placed on the chief executive of the project and these reports should not be treated as of less importance than the project itself. (In this connection, attention of the committee was drawn to numerous pamphlets which had been issued by the Bhakra authorities on occasions of visiting dignitaries, but none of them catered to the need of engineers interested in the lessons learnt from the construction of the dam.) Specific provision should be made for adequate staff right from the beginning of a project to help the chief executive in this task.

3.3 The committee recognised that the reading habit among Indian engineers had to be vigorously stimulated. Besides, there was a need to bring out periodicals containing original Indian contributions to engineering presented in an impressive and readable manner. Since the country was launching on large-scale construction programmes, the committee feels that there is room for starting in India, with the blessings of the Planning Commission, an independent journal on engineering construction economy, which should be produced attractively and made available to engineers at all levels at a reasonable price. It should cover all the sectors of building construction, such as roads, railways, waterways, multipurpose projects, public works, private construction of houses, ware-houses, factories and so on. The aims of the journal would be:

(i) to promote reading habit among Indian engineers.

(ii) to publish articles about better training, better methodology, better quality control, greater economy, higher productivity, standardization etc.

(iii) to bring to the knowledge of the engineering profession the remarkable achievements in construction projects currently made in India which often lay buried in the archives of many projects. (As an example may be mentioned the outstanding feat achieved by Indian engineers in plugging the leak in the Bhakra Nangal dam a few years ago, the details of which are still not known to the engineering profession either in India or elsewhere in the world).

(iv) to publish case histories of construction economy achieved in other countries.

(v) if possible, also to have an abstracting service limited to selected items relating to construction economy.

3.3.1 The committee suggests that the management of the journal should be in the hands of a person with initiative and drive and that it might have to be subsidized in early stages. It is recognized that the jorurnal could be successful only if a person of the right calibre could be found and induced to take charge of it, but the committee feels that the attempt would be worthwhile.

3.4 The committee recommends that governmental agencies concerned with publicity, such as the Press Information Bureau, the All India Radio and others should themselves undertake, as a part of their programmes, to highlight construction economies achieved in various projects and works, and wherever necessary give prominence to the names of the individuals responsible for bringing about such economies. For this purpose, these agencies should name an officer from among their own staff who would be charged with the responsibility to give special attention to publicizing achievements in construction economy. A senior officer in the Planning Commission may also be named to act as the coordinator between these departments and the construction projects and to give advice about the publicity material.

Proper Utilisation of Existing Skilled Personnel

R. R. Daniel*

The requirement of an adequate number of skilled personnel in all important areas of national activity is vital for the rapid and balanced development of any new Nation. It is also obvious that, in order to make them effective, we need necessary Resources, enlightened Management and an efficient Training system. In a country like ours with limited resources and limited number of skilled personnel, it becomes of paramount importance to maximise the services of such available personnel. While there are many other associated problems of equal importance such as talent search, training systems, prevention of brain drain, etc. we would restrict our enquiry here to the skilled personnel existing in the country at present times, some reasons for the inadequate and inefficient utilisation of their services and some suggestions as to how best to improve them. We first enumerate below some of the important reasons, which according to us, lead to inadequate and inefficient utilisation of skilled personnel in the country.

1. Not selecting the best available man for the job.
2. Red Tape involved, and the consequent slowing down of all work.
3. Systems which involve loading of Skilled Personnel with too much of administrative work.
4. Lack of administrators who understand the language of the specialist.
5. Unnecessary duplication of work.
6. Ill-defined final objectives of schemes.
7. Lack of appreciation of good work accomplished.
8. Lack of sufficient encouragement, and often the existence of direct or indirect discouragement of Skilled Personnel, for taking part in consultancy.
9. Absence of some sort of contract system resulting in the specialist spending too much valuable time in developing or perfecting conventional and routine accessories or methods.
10. Inadequate contact between R&D and Production units.
11. Insufficient opportunities for specialists to meet and exchange information and ideas. Our Conferences and meetings often end up as a platform for "Veterans" to sermonise to the younger generation instead being a forum for the active specialist.
12. Skilled worker not associated with teaching at some appropriate level. (We include under teaching, writing of books and articles as well). Teaching is one of the most intellectually satisfying jobs and helps in keeping the feed back to education vigorous.
13. The specialist concerned is sometimes unaware or not fully aware of areas where he can usefully contribute by way of consultation or part time participation.
14. Inadequate facilities and opportunities provided at an individual level to bring the best out of the person concerned.

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15. Sometimes the limited available resources are evenly distributed among too many projects in an Institution or among a group of institutions without any consideration of relative priorities between them; this leads to all round inefficiency. (Often this is done as a "simple solution" of the problem by the top men).

It is revealing that all the above reasons are linked directly or indirectly to shortcomings in Management, scientific and/or administrative. The solution therefore seems obvious and almost simple, namely one of setting up the right kind of Management. Here we are of the opinion that the following two aspects are of dominating importance: (i) Evolving a new cadre of scientist—managers whose duty ultimately will be administration. (ii) To evolve a suitable machinery through which the Government can get access to the right kind of advice from scientists and technologists whenever necessary regarding national problems.

We do not wish to elaborate on all the aspects enumerated above because many of them have been dealt with at different places by experts. However, we would like to emphasize the importance of Consultancy (items 8 and 13) and Contract System (item 9) which at present are not sufficiently practised; in fact their importance and usefulness have often been not even fully realised.

Two obstacles which come in the way of practising Consultancy effectively are: (i) the lack of a sufficiently extensive system by which the right kind of expert can be brought in for a job and (ii) administrative and other hurdles which the expert has to tackle before taking up the assignment. Here we trust that the setting up of some kind of Regional Consultancy Centres on lines similar to Employment Exchanges might be beneficial in providing expert advice for many problems facing Industry and production, big and small. (This kind of a centre can also be set up as a Private enterprise). One may also think of a third reason which stands in the way of promoting Consultancy namely the lack of proper awareness on the part of the producer on the benefits of Consultancy. This again is partly due to the fact that Industry has not made much effort to understand where science comes in, and the scientist has not taken enough trouble to make the industrialist aware of his own role. An effective functioning of an organisation like the Science Congress on a regional basis, meeting many times in a year, might provide a suitable forum to achieve this.

The Contract System can be practised with great advantage particularly in certain areas of Development. Quite often, it is of rather routine nature, requiring a certain amount of ingenuity on the part of the worker. If such jobs are given on a contract basis to a smaller unit (usually a private enterprise), it would free the specialist to tackle more important problems. At the same time such a system will breed skill and competence in a chain reaction.

Science Round Table—Some Observations*

VIKRAM SARABHAI**

1. Two Cultures

Decentralisation, delegation, reporting and control, evaluation and motivation are aspects of the management system closely related to the objective of an organisation. They also bear the imprint of assumptions which are made concerning the task. At one end of the spectrum are certain administrative services, acting on past precedents and traditions providing security and continuity, impersonalised to the extent that if one person is substituted by another, every one knows how the successor will behave and operate under a given set of circumstances. At the other end, there are organisations based on research and development, involving individuals who act on insights and hunches, non-conformists questioning assumptions, innovating and learning. The two extremes require organisations and working cultures which are rather different. Yet many tasks encountered in the contemporary world call for organisations, wherein creative thinking and innovation are essential ingredients of survival as well as growth. The diversity of tasks that require to be performed within the governmental framework require individuals who are not only sensitive to the needs of the two cultures but can provide a dynamic relationship to the conflicting systems. In this context, the study of atomic energy in India is of relevance, for a culture appropriate to research and developmental tasks was established within the framework of government.

2. Institutions for Innovation

Institutions for innovations require organisations built around men. No organisation chart should stand in the way of recognising and rewarding talent.

3. Control of Peers

In professional groups, scientists, engineers and others, it is important to recognise that motivation and control is largely inherent and contained in professional commitments. In organisations using large professional groups, the role of administration has largely become one of service and not of control. This requires a basic change in attitudes rather than a change in procedures and practices. Control is exercised through discussion and judgement of peers. Money, hierarchical status and power are important needs for most, but to scientists and professional groups the need for autonomy of working conditions and self-development are also important factors.

4. Formal and Real Organisation

The early beginnings of any institution are crucial, and the 'culture' (or lack of it) brought by the first entrants play a significant role in establishing norms,

* Largely based on paper : "Organisation for Developmental Tasks : Atomic Energy Commission of India" by Kamla Chowdhry and Vikram Sarabhai and on Convocation Address to the Indian Institute of Management, Ahmedabad April 1967, delivered by Vikram Sarabhai.

** Chairman, Atomic Energy Commission

procedures and practices in the organisation. The numbers should be large enough to achieve a critical size to permit positive interactions. An inappropriate social culture can also be transferred by appointing persons from a different working 'culture'. In this connection, the appointment in a key position or in large numbers at lower positions, of competent Government officials whose experience is primarily derived from routine administration, in research organisations or in industrial enterprises, is very questionable.

5. Administrative Practices

The existing government procedures of selection, promotion, evaluation, budgetary controls, buying of supplies and equipment are highly inappopriate to the effective functioning of scientific laboratories and industries involving complex technologies.

6. Professional Role of Chief Executive

In research laboratories, and in other develomental tasks it seems important that the Chief Executive, besides policy-making and administration, maintain a direct contact with his professional role. The creation of administrative practices appropriate to a given technology or set of tasks comes with familiarity and knowledge-of-acquaintance of the technology or tasks concerned.

7. Strategic Decision Making Body

The body to which the Chief Executive refers for policy and strategic decisions must be compact in size and consist of members chosen for their expertise and roles, rather than from a representational angle.

8. Basic, Applied and Developmental Research Related to Industrial Activity

There is a need for a constant interplay between the basic sciences, technology and industrial practice if economic progress is to result from the activity undertaken. The wearing of several hats by the same person, and the mobility of personnel from one type of activity to another have undoubtedly provided the impetus for growth in the projects of the Department of Atomic Energy. We may contrast this with the practice prevalent in higher educational institutions for basic sciences and technology and national laboratories where the work of applying the results of research to practical ends had to be done through other units, not organically related to the laboratories or the men that work in them.

9. Organisation and Men : and Inter-Relatedness of Factors for Development

The various factors indicated earlier are interrelated and mutually dependent. A change in one influences the total scheme of things, for in organisational structures and culture, the whole is more than the sum of its parts. Structures, procedures and techniques are important but these must be sustained by a cluster of attitudes conveying care, trust and nurturance on the part of responsible persons.

SCIENCE ROUND TABLE

Y. NAYUDAMMA*

1. **Science Policy goals and priorities**

1.1 Science is the pursuit and accumulation of knowledge, and technology is the application and utilisation of such knowledge.

1.2 Technology and science are not two separate and autonomous entities. But these are a closely coupled and integrated system.

1.3 The purpose of science and technology is to create material wealth and to meet the material needs of the nation. Nation is not soil. Nation is people.

1.4 Science and technology should be wedded to social technology. Science and technology are not for the people but with and by the people.

1.5 Science and technology appear to be among the best tools to bridge the gap and growing disparity between advanced and developing countries. The revolution of rising expectations can only be met by a scientific and technological revolution.

1.6 For Science to grow, a scientific temper and rational approach in the community are essential. It is the attitude of mind — resilient change, and resistant to dogma, prejudice, pride and jealousy. Scientists today are not that scientific after all.

1.7 Science for science sake is now out of date. Also the spiritual content is irrelevant. Science is not only to know but to do something about it. Science is a strategy of action.

1.8 Research in basic science develops the highest type of creative minds and experimental needs. Today's basic research is tomorrow's applied research. Therefore, basic and applied research should go hand in hand.

1.9 As it is difficult to finance a lot of basic research and as there is more need for applied research there should be some selectivity. This necessitates a selective approach in the choice of fields and men. This basic research may be (a) oriented to National needs, (b) the selection of creative people and the development of schools around them.

1.10 **Problems of perception**

Even in the applied field, selectivity is important in the choice of research. It is necessary to identify clearly (a) fields of science that are likely to offer greater opportunities for the country's advancement (b) fields of industrial products where science catalyses (c) choose products that will yield quick returns, and (d) integrate the nation's needs with research needs.

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2. **Research Yields and Research Evaluations**

To plan programmes and fix priorities, one should have the necessary tools and techniques to evaluate research outputs, yields and their utilisation.

3. **The Type of the Industrial Research Institutes and evaluation of the performance**

A working paper prepared by Lawrence W. Bass, for the U.N. Industrial Development Organisation ID/WG.2/R.6. and ID/WG. 2R/7, as presented by the author at the workshop of Managers of Industrial Research Institute in Developing countries, Athens, Greece, 4-18 July '67, would give an indication of the lines of approach. With suitable modification they may be readily applied to our research laboratories.

4. **Indigenous versus foreign collaboration**

Many a developing country faces the problem at one time or the other in regard to the import of knowhow and foreign collaboration. This provokes different reactions from industry, research institutions and the government. Industry is not sure of the time when indigenous knowhow will be made available whereas it could get it from external sources on reasonable terms saving time, uncertainty and also having the benefit of tried-out processes, turn-key jobs and internationally known brand names for ready sales. But the indiscriminate import of technology will go contrary to the development and growth of the country's progress: Imported technology is more suited to conditions in the countries from which it is imported and is not necessarily adopted to the local resources, genius and skills of the people. Sometimes, outdated and outmoded processes and equipment are imported and at other times, indigenous industry may have to be continuously dependent upon the imported knowhow. Tying up of local industry to foreign practices militates against contact with indigenous research.

No country can afford to be self-reliant in respect of technical knowhow and there should be international trading in it. Import of technology should be permitted only on a rational basis reckoning the present and the future requirements of the industry. A techno-economic evaluation of different knowhow proposals has to be carried out. Where technology is readily available or likely to be available in reasonable time or where a foreign collaboration already exists in that given field, the import of further knowhow should not be permitted. Once foreign collaboration is permitted, the capacity required should be built up in the country on the basis of multiple units based on this knowhow and making this knowledge available for a number of other purposes. This would create competition between the different groups and productivity will increase, apart from the large saving in the import of components, maintenance parts etc. Steps also may be taken simultaneously for duplication of the knowhow and design of the imported equipment. Further development and improvement on the imported knowhow must be ensured by continuous research by industry within the country. The obtaining of imported knowhow may also be channelised through an agency instead of leaving it to each entrepreneur. Instead of each one seeking a separate technical collaboration with foreign firms, a common approach must be made which would save a considerable amount of foreign exchange, lead to standardised plant and equipment in the country and also to healthy competition as each unit would be working under similar conditions. It is also time Indians should begin to trust Indians and rely on their own capacities rather than continually depend upon others.

5. **Application and utilisation of research**

My ideas on the application and utilisation of research are contained in my paper published in MINERVA.

6. **Scientific Planning and Organisation**

There should be a National Science Council composed of members drawn from different schools of scientific thought in industrial development. The members of this council, may be at least half, should be elected from among working scientists. The present method of nominations and musical chairs should be avoided. It is also necessary that all branches of science, must come under this umbrella including atomic energy, agricultural research and even a good amount of defence science.

The business of this National Council shall be the formulation of policy regarding science and technology for the nation; identification of problems; national priorities, the allocation of funds, the conversion of national needs into technological projects, to match men with the jobs, with objectives related to the experience and the expertise available.

This Council may even set up expert panels to define areas and objects, translate these into technological projects, assess the resources and skills needed to complete these projects, set out priorities in the light of the resources available, and decide the type of knowhow, machinery etc., that require to be imported.

These panels need not be full time and they should not sit in Delhi. Pick and choose the brains for a particular purpose till the job is complete.

7. **Scientific Advisory Committee to the Cabinet**

The only way open is to have a Scientific Advisory Committee composed of only a few members. A good proportion of this Committee should be from working scientists.

The Scientific Advisory Committee shall be responsible for the translation of the policy decisions set up by the Science Council into administrative decisions and implementation of the projects drawn up based on national needs. This committee should be vested with the necessary authority to deal with every ministry and to ensure that the decisions and the projects are implemented.

National Science Council is responsible for policies etc. and responsible to Scientific Advisory Committee. Scientific Advisory Committee is responsible for decisions, implementation, etc. and responsible to cabinet.

8. **Administration and Implementation of Science policies**

In regard to the implementation, we may have to consider radical changes once the problem is well identified, the priorities set and the research and development task forces established, these should be entrusted to a leader who should be made responsible for the progress of the project. The project should cut across Ministries, laboratories or industries. The essential thing is proper identification and definition of a project and locating a man who can deliver the goods. Then, the responsibility and authority should be defined and delegated to the leader and to his colleagues at all levels. Once national priorities are fixed, the job should be broken into various components, the inputs should be analysed and provided, the leader named and given full responsibility and authority. Initiative and experimentation is the basis of efficiency. Our whole organisational and administrative set up is based on mistrust. Distrust kills initiative and therefore there is no climate for experimentation, initiative or efficiency. The project leader must be judged by the total performance of the project.

Annexure I

SCIENTIFIC ADVISORY COMMITTEE TO THE CABINET (SACC)

The Committee was established in 1956. Its terms of reference are:

(*i*) To advise the Cabinet

(*a*) in the formulation and implementation of the Government's science policy ;

(*b*) on the coordination of scientific work between the various ministries and semi-government and non-governmental scientific institutions in the country including the scientific and technical departments of the universities ;

(*c*) on scientific and technical cooperation with other countries and with international scientific and technical organisations, and

(*d*) on such matters as may be referred to it.

(*ii*) To place before the Cabinet such proposals and advice that may improve and develop scientific and technical work in the country.

The Committee consists of 15 members—scientists and technologists. Since the death of Dr. Homi Bhabha, the Cabinet Secretary has been Chairman of SACC.

Annexure II

EXCERPTS FROM FOUNDER MEMORIAL LECTURE OF THE SHRI RAM INSTITUTE FOR INDUSTRIAL RESEARCH, 1967

by D. S. Kothari

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Science Policy

Interaction between science and society, between science and Government is a very complex thing. Many aspects of this interaction are difficult to define with any precision. Even in the advanced countries the mechanism for formulation of science policy and goals is still in a most rudimentary stage. Partly the difficulty is inherent in the situation, because of the inherent unpredictability of fundamental discoveries in science which in a few years may have an altogether new and far-reaching impact on the life and progress of society. Also, and essentially, the difficulty arises from the simple fact that science policy almost invariably goes far beyond science. It involves complex political and social issues and decisions. Science policy has two components, somewhat related but distinct. It is concerned with policy about pursuit and development of science, but it is even more concerned with utilization of science to meet national needs and goals. The national goals which involve science range over a wide spectrum: agriculture and industry, improvement and control of environment, medical care, science education, computers and automation, population control, and so on. Whatever the resources, big or small, there is always the problem of deciding what not to do in order that something can be done with reasonable speed and chances of success. If resources are distributed over everything worthwhile which one wishes to do, then the effort will get so diffused that nothing really would be done. This problem of concentration of effort is a basic issue for every country, and if anything, it is crucial for a developing country like ours. Even advanced countries (such as the U.K.) are now finding that several areas of big science such as high energy physics and space research are now getting almost beyond their resources.

It is most important that there should be some mechanism whereby Government, at the highest level, can get as competent objective and unbiased an advice as possible on matters relating to science policy. An important aspect of science policy which needs serious examination is about the respective roles and missions of the various agencies in the country concerned with the promotion and use of science, such as the C.S.I.R. and other Research Councils, the U.G.C., the A.E.C., the Defence Research Organisation and other Government departments concerned with science.

At present, quite a few of the agencies have moved into fields and assumed responsibilities which go beyond their respective purposes and main functions. In all countries, and especially in a developing one, there is a marked tendency and danger for this to happen. Some of the organisations, with passage of time and the operation of the Parkinsonian law of proliferation, become too big and amorphous to make efficient contribution to science and development of the country. A situation can even arise when the organisations forget their proper role and responsibilities. Where aims, targets and responsibilities are ill-defined, an unbiased assessment of work and evaluation of achievements of the various agencies becomes near impossible. In such a situation the relative allocation of the slender available resources between the competing agencies depends more on the pulls and prestige of the leaders of those agencies on the current international fashion in science than on the worth-whileness of the agencies' programmes and their contribution to meet national needs. In the context of what has been said above it is relevant to recall that recently in the U.K., the D.S.I.R. (which corresponds to our C.S.I.R.) has been abolished. The functions of the D.S.I.R. relating to fundamental research have been transferred to a new Science Research Council. Many of its functions concerned with applied science and industry have been taken over by the new Ministry of Technology.

The usual mechanism is to have a high level Science Advisory Committee. For such a committee to function properly, it is perhaps necessary that a major part of its membership belongs to persons who enjoy confidence of the scientific community, but are themselves not in charge of big science agencies or science related departments. Another important consideration is that the committee should include among its members economists, social scientists and persons knowledgeable in the fields of industry and management. When the committee consists largely of people who themselves are in charge of science using agencies, it becomes almost impossible for the committee to go into any critical discussion of problems and to reach objective and unbiased decisions. Viewed in this light, the Science Advisory Committee in our country needs substantial reorganisation as regards its composition and functioning.

The support for science depends much on the understanding and vision of the political leadership, and on the general awareness in the country, about the role, strength and limitations of science. It would serve a distinctly useful purpose if a 'Science Report' dealing with the progress of science and important questions bearing on science policy, was placed annually before our Parliament. A discussion in the House on such a report would serve a valuable purpose. The C.S.I.R. could be assigned the responsibility for preparing the report for submission to Parliament.

It is important to recognise that in an age of science and technology, universities in advanced as also in developing countries have acquired a new role and a new significance. Through the powerful and symbiotic combination of teaching and research, education and discovery, youth and age, orthodoxy and heterodoxy, universities in the modern world make a contribution to science and its growth as no other organisation or agency can or does. The experience of more than a century, starting with the great German Universities has demonstrated beyond doubt that teaching and research flourish best in combination. The best of either is achieved in an atmosphere where both are cultivated, and in this invigorating combination of teaching and research, lies the real strength of universities.

A face-to-face confrontation and critical dialogue between the professors and their bright inquisitive students, without the inhibition and constraints which generally operate in non-university type institutions, acts as a powerful stimulus to original thinking and creativity and helps to open new horizons of thoughts. Also scientific work is now becoming increasingly more and more of a team effort, and in promoting team work, a university atmosphere has a distinct advantage. When there is shortage of trained men of first-rate ability, as we face today, it is wiser to invest them generally in the universities than elsewhere. This would result in a high degree of multiplication effect, as the top men would not only contribute to research but also the training of the younger generation. It is important to ensure that the effort exceeds a certain critical mass so that it can generate and sustain a sort of chain process producing many more and more of able men. For the progress of science, education and research, and for the improvement of its quality, it should be almost a basic policy that university type of work should not be done in government establishments or other institutions which are divorced from teaching. This is a matter which needs serious attention. Laboratories for scientific work outside the universities, unless these happen to be directly concerned with applied research and for a clearly defined mission, are unlikey to have a fruitful and vigorous life of more than a few decades (if not less). This arises from a variety of causes. The top men around whom the laboratory was originally organised, may have left or would have passed the prime period of their creative activity and inspiration; the laboratory, unlike a university, lacks the continuing stimulus and challenge of fresh students joining every year; and the purpose for which the laboratory was set up may no longer be relevant as entirely new lines of development may have made to some extent obsolete the field of work for the laboratory was originally set up. A deteriorating laboratory, whatever the cause of its degeneration, always poses a serious problem. What is to be done with the expensive equipment and the huge staff ? It often tends to bolster up its scientifically weak case by asking for more funds, more buildings, and more men. Unable to compete in quality science, it shifts its endeavour to compete in terms of prestige buildings and expensive but not-to-be used equipment. It tends to believe that people would judge the quality of its work by the quality of the buildings—marble floors and high salaries, may be taken in as an index of quality work and quality scientists. It is much easier and quicker to achieve high quality, even in international standards, with regard to buildings and imported equipment than in science education and research. Spending money, specially someone else's money, is far easier than spending thought. In a developing country such as ours, the highest priority must go to the strengthening of the universities. If research institutions outside the universities expand too rapidly it would result in depleting the universities of their competent men, and may be also of the money which should go to them. In the long run, weak universities would inevitably weaken the entire research effort of the country.

It is often suggested that one way of meeting the situation would be to encourage national laboratories and other research institutes outside universities to undertake some teaching work either in association with universities or on their own. This should be fully supported and encouraged. At the same time it is a relevant question to ask as to what extent such an arrangement would strengthen the universities. As a recent editorial in Nature on the U.K. Report of the Working Committee on Liaison between Universities and Government Research Establishments (Sutherland Committee Report — 1967) has pointed out : "As things

(*Contd. on page* 72)

Annexure III

Government of India
SCIENTIFIC POLICY RESOLUTION

No. 131/CF/57.—The key to national prosperity, apart from the spirit of the people, lies, in the modern age, in the effective combination of three factors, technology, raw materials and capital, of which the first is perhaps the most important, since the creation and adoption of new scientific techniques can, in fact, make up for a deficiency in natural resources, and reduce the demands on capital. But technology can only grow out of the study of science and its applications.

2. The dominating feature of the contemporary world is the intense cultivation of science on a large scale, and its application to meet a country's requirements. It is this, which, for the first time in man's history, has given to the common man in countries advanced in science a standard of living and social and cultural amenities, which were once confined to a very small privileged minority of the population. Science has led to the growth and diffusion of culture to an extent never possible before. It has not only radically altered man's material environment, but, what is of still deeper significance, it has provided new tools of thought and has extended man's mental horizon. It has thus influenced even the basic values of life, and given to civilization a new vitality and a new dynamism.

3. It is only through the scientific approach and method and the use of scientific knowledge that reasonable material and cultural amenities and services can be provided for every member of the community, and it is out of a recognition of this possibility that the idea of a welfare state has grown. It is characteristic of the present world that the progress towards the practical realisation of a welfare state differs widely from country to country in direct relation to the extent of industrialisation and the effort and resources applied in the pursuit of science.

4. The wealth and prosperity of a nation depend on the effective utilisation of its human and material resources through industrialisation. The use of human material for industrialisation demands its education in science and training in technical skills. Industry opens up possibilities of greater fulfilment for the individual. India's enormous resources of man-power can only become an asset in the modern world when trained and educated.

5. Science and technology can make up for deficiencies in raw materials by providing substitutes, or, indeed, by providing skills which can be exported in return for raw materials. In industrialising a country, a heavy price has to be paid in importing science and technogy in the form of plant and machinery, highly paid personnel and technical consultants. An early and large scale development of science and technology in the country could therefore greatly reduce the drain on capital during the early and critical stages of industrialisation.

6. Science has developed at an ever-increasing pace since the beginning of the century, so that the gap between the advanced and backward countries has widened more and more. It is only by adopting the most vigorous measures and by

putting forward our utmost effort into the development of science that we can bridge the gap. It is an inherent obligation of a great country like India, with its tradition of scholarship and original thinking and its great cultural heritage, to participate fully in the march of science, which is probably mankind's greatest enterprise today.

7. The Government of India have accordingly decided that the aims of their scientific policy will be—

(*i*) to foster, promote, and sustain by all appropriate means the cultivation of science, and scientific research in all its aspects—pure, applied and educational;

(*ii*) to ensure an adequate supply, within the country, of research scientists of the highest quality, and to recognize their work as an important component of the strength of the nation.

(*iii*) to encourage, and initiate, with all possible speed, programmes for the training of scientific and technical personnel, on a scale adequate to fulfil the country's needs in science and education, agriculture and industry, and defence;

(*iv*) to ensure that the creative talent of men and women is encouraged and finds scope in scientific activity;

(*v*) to encourage individual initiative for the acquisition and dissemination of knowledge and for the discovery of new knowledge, in an atmosphere of economic freedom.

(*vi*) and, in general, to secure for the people of the country all the benefits that can accrue from the acquisition and application of scientific knowledge.

The Government of India have decided to pursue and accomplish these aims by offering good conditions of service to scientists and according them an honoured position, by associating scientists with the formulation of policies, and by taking such other measures as may be deemed necessary from time to time.

(*Contd. from page* 70)

are, the evidence, the Committee has compiled of the willingness of the establishments to help with teaching, can be interpreted not only as a proof of goodwill but also as a sign that the establishments have been endowed with resources which might have been better spent in universities."

Annexure IV

EDUCATION COMMISSION ON SCIENCE EDUCATION AND RESEARCH

* * *

National Science Policy

16.84 Science policy and decisions concerning science now play such a vital role in the national economy and defence that it is most important for the governmental authorities at the highest level to ensure that on major scientific issues they can get advice which is as impartial and objective as it possibly can be. It is important to have an advisory body which is appropriate for this purpose. Such a body should have on it, besides, heads of major agencies concerned with scientific research, persons who have a high standing and regard in their professions and who inspire general confidence — a proportion of these members should be distinguished young scientists in their thirties. The number of such persons should be not less than the agency heads. They could be from the universities, research institutions (government or non-government), industry and public life. The advisory body should also have on it not only scientists and technologists but also economists and social scientists and persons with experience of industry and management.

16.85 A fundamental concern of science research policy is the relative allocation of priorities with reference to different sectors of scientific effort, both in terms of subjects and in terms of operating agencies. This is a problem which involves vital scientific issues, but it goes beyond science. It involves important economic and political considerations. The resources in men and material available at any time for R & D are severely limited. This is so even for affluent countries. The number of able scientists and engineers is often the critical factor in determining the total volume of the R & D effort. Difficult and sometimes unpleasant choices have to be made among the many competing claims on the use of the available talent and professional manpower. This is inevitable, and a responsibility which cannot be shirked. To lay down effective and operational priorities is not at all an easy thing. It needs a relatively well defined formation of the national goals and objectives, and it needs hard, courageous and imaginative thinking.

16.86. The present Scientific Advisory Committee to the Cabinet cannot perhaps be considered to have effectively performed the functions envisaged above, no matter what its terms of reference are. The Committee is mainly constituted of representatives of the important research organizations in the country. This makes, to say the least, an objective and critical examination of issues of national research policy difficult. The members are often too directly involved to be able to take an objective and detached view. In most of the advanced countries the top Advisory Committee is composed of people who have no 'vested interests' in an institution to defend or to fight for.

16.87. We recommend that the Scientific Advisory Committee be reorganized and provided with an effective secretariat with a professional component adequate to its tasks. The Committee should be in a position to assess the broad scientific needs of the country including the universities and advise government on science policy and allocation of total resources between different sectors of scientific activities.

The task of this body should be to review continuously the national research policy situation.

16.88. Recently the Atomic Energy Department has undertaken a programme for research in radio astronomy and also in the field of molecular biology. The interest of the AEC in these fields is to be welcomed. But it needs to be stressed that these fields of research should primarily be developed and supported in the universities unless there be compelling reasons to the contrary (we are not aware of such reasons).

16.89. We should like at this stage to say a word about the Research Councils. We have the Council of Scientific and Industrial Research, the Indian Council of Agricultural Research, the Medical Research Council, and the Defence Research Council. It is our view that bodies concerned with science policy and implementation and which have executive and managerial functions requiring detailed and expert examination of diverse issues, should ordinarily have professional scientists, engineers or science administrators of high standing as their chairmen.

16.90. We may mention that in most of the scientifically advanced countries the organization at the national and governmental levels of research has undergone drastic changes during the last five years or so. In the UK, following the Trend Committee Report, the Department of Scientific and Industrial Research (which corresponds to the CSIR) has been completely overhauled. In its place there has been constituted the Science Research Council which deals with those functions of the DSIR which were concerned with basic research, fellowship awards and research grants to universities. Several of the DSIR laboratories, including the National Physical Laboratory have been transferred to the new Ministry of Technology with a view to bring the laboratories into closer relationship with industry. The AEC is with the Ministry of Technology. There is also an Advisory Council on Science Policy.

16.91 It should be a major task of the national research policy, and policies of the universities to provide a 'climate' conducive to research, and to prevent and eliminate, through energetic and public measures, all dangers and infringements of autonomy and freedom of action in research. It should be recognized that all this needs delibertate effort, and it also takes time. To quote Michael Polyani: 'Those who have visited the parts of the world where scientific life is just beginning, know the back-breaking struggle that the lack of scientific tradition imposes on the pioneers. Here research work stagnates for lack of stimulus, there it runs wild in the absence of any proper directive influence. Unsound reputation grows like mushrooms, based on nothing but common place achievements, or even more on empty boasts—However rich the fund of local genius may be, such environments will fail to bring it to fruition.'

16.92 In the case of scientific work, zest and enthusiasm of high quality are extremely important. This needs freedom from petty worries and distractions, a proper research climate and a good morale among scientists. It is no easy thing to build scientific institutions with international reputation. These demand single-minded effort, devotion and dedication.

16.93. In determining our priorities for research we should be guided by our own national needs and not be unduly influenced by what may happen to be the current fashion in science. If space research and nuclear physics are given a high place in a nation's programme of research, it will be futile to expect that the young talent will elect agriculture or industrial research. If marble floors and possession of expensive equipment become the outer symbols of scientific status, a waste of national resources in the name of science and research becomes almost inevitable. Fred Hoyle has observed: 'People who work in marvellous buildings are dominated by those buildings, whereas it is the other way round for people who work in rabbit warrens. The builders of the great European cathedrals knew this perfectly well. Walk into a big cathedral and it wipes your brain clean of all thoughts. The same thing happens when you walk into these wonderful modern office blocks. The same thing happens all too easily in big science.*

Science Academy

16.94. In the scientific life of a country a national organization or academy of sciences occupies an exceedingly important place. In some ways its role is crucial for the growth of science education and research. While this is not the place to go into the subject at any length; we feel that a brief reference is necessary.

16.95. In India, the role of a National Academy is performed partly by the National Institute of Sciences. However, it may need some drastic reorganisation, if the Institute is to exercise a vigorous leadership in science and play a more significant role in the scientific activities of the nation. In recent decades the demarcation between science and technology has become increasingly thin and artificial, and for this and other reasons, it may be desirable to widen the scope of the fellowship and bring into the Institute more engineers and technologists. Further, if the Institute is to be seriously concerned with the inter-action between science, economic growth and national development, it would be useful to extend the fellowship to economists and social scientists. This is the practice in several academies, the most important being the Soviet Academy of Science.

16.96. In the above context, we may refer also to the Science Council of Japan established after World War II, as it has some features which could perhaps be usefully incorporated in our own organizations. The Council is the legal and official representative body of the scientists of Japan. The JSC has no direct control over research. Its function is to determine what is best for science in Japan and to advise government accordingly. It is under the jurisdiction of the Prime Minister. It has seven divisions : (1) literature, philosophy, pedagogy, psychology and socialogy, history (2) law, political science; (3) economics, commerce and business administration; (4) pure science; (5) engineering; (6) agriculture; (7) medicine, dentistry, pharmacology. The 210 members of the Council, 30 from each of the seven divisions, hold office for three years. They are elected by a nationwide constituency of electors who are either graduates of at least two years standing or possess five or more years of actual research experience. The Council has a Management Committee of 31 members. The constitution of the Japanese Council is highly democratic. In these days when science impinges on broad issues of economic and national problems, it is desirable that a national organization of scientists is not controlled entirely by the

*Fred Hoyle 'Of Men and Galaxies', University of Washington.

scientific aristocracy, as it were but the entire scientific community gets a chance to participate in the life and work of the organization.

16.97 Many of the major issues of science policy involve considerations which go outside the strict domain of science. In view of this, and other reasons, it is an advantage for a national organization which claims to speak on behalf of the scientific community to involve in its deliberations some elected representatives of the entire fraternity of science. For a country of the size of India it may not be possible to adopt the pattern of the Science Council of Japan, but the possibility could be explored of associating with the National Institute of Sciences a small number of scientists (not fellows of the Institute) elected by the scientific community. The number of such members could be limited to about a third of the total strength of the Council. Such an arrangement would help the process of activization of science by bringing closer contact and participation between its different components.

16.98. A national academy has also a major function in promoting international relations in science. Such a body represents the country on international scientific organizations such as the International Council of Scientific Unions and its various committees. India is almost the solitary case of a country which is not represented on the ICSU by a professional academy but by the Government. It is worth mentioning that science academies often help in furthering cooperation between countries amongst which political relations may not be normal.*

CONCLUSION

16.99 The broad conclusions are simple and apparent. But often it is the obvious things which are the hardest to implement :

—Strengthening of university science and research should be conceived as a fundamental goal of national science policy.

—In the universities, good work, good teaching and good research should be energetically and generously supported at all levels. In science, the output in terms of achievement is directly proportional to the input in terms of hard and honest work. Work of poor quality and pseudoresearch should be ruthlessly discouraged.

—Contacts between the universities and national laboratories, scientific government departments, and industry should be vigorously promoted and strengthened. Any one who has a real competency and willingness to participate in university work should be encouraged to do so. So great and urgent is our need that all resources need to be fully exploited.

—'Right climate', leadership and dedication are important factors in promoting team-work and in generating scientific work of high quality. Able and gifted men should be given every opportunity for concentrated and sustained work free from petty worries and distractions. Informal and enlightened public support of science (but not lip service or uncritical adoration) is an essential factor in creating a proper climate for scientific work. Science should not only be held in high regard but it should also enjoy the confidence of the public.The universities have an obligation and a role in promoting public awareness and under-

*For instance, the USA Academy of Sciences has shown much initiative in exploring the possibilities of scientific cooperation with the Peoples' Republic of China. (*Science*, June 17, 1966).

standing of the organization and achievement of science in the country, its strengths and weaknesses.

—In science departments, the administrative load and 'routine' should be cut down to a minimum.

—Teaching and research are mutually supporting activities. There is no real border line between them—they merge into each other. In their symbiotic combination lies the unique and peculiar strength of the universities.

—Our resources are limited, so one has to spend more thought to get more out of our resources—spending thought is more difficult than spending money.

16.100 Science education and research are crucial to the entire developmental process of the country. The experience of several countries, notably the USSR and Japan has shown that it is only on the basis of purposeful science education and research that a stagnant economy can be radically transformed into an industrial economy in a comparatively short time. The highest priority therefore has to be given to the improvement in the quality, as also a balanced expansion, of science education and research. The responsibility for this rests primarily with the Central Government and the scientific agencies closely associated with it. They alone can provide the necessary leadership and resources.

16.101. We cannot conclude this chapter better than by recalling the memorable words of Jawaharlal Nehru :

Science has developed at an ever-increasing pace since the beginning of the century, so that the gap between the advanced and backward countries has widened more and more. It is only by adopting the most vigorous measures and by putting forward our utmost effort into the development of science that we can bridge the gap. It is an inherent obligation of a great country like India, with its traditions of scholarship and original thinking and its great cultural heritage, to participate fully in the march of science, which is probably mankind's greatest enterprise today.*

*Statement in Parliament on the Science Policy Resolution.

Annexure V

INVITEES TO THE SCIENCE ROUND TABLE

1. Achaya, Dr. K.T.,
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HYDERABAD.

2. Atma Ram, Dr.,
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12. Ghatage, Dr. V.M.,
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13. Ghosh, Dr. A.N.
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38. Singh, Dr. Amarjit,
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39. Singh, Maj.-Gen. Harkirat,
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40. Singh, Shri Jagjit,
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47. Govindachari, Dr. T. R., Director, CIBA Research Centre, BOMBAY.

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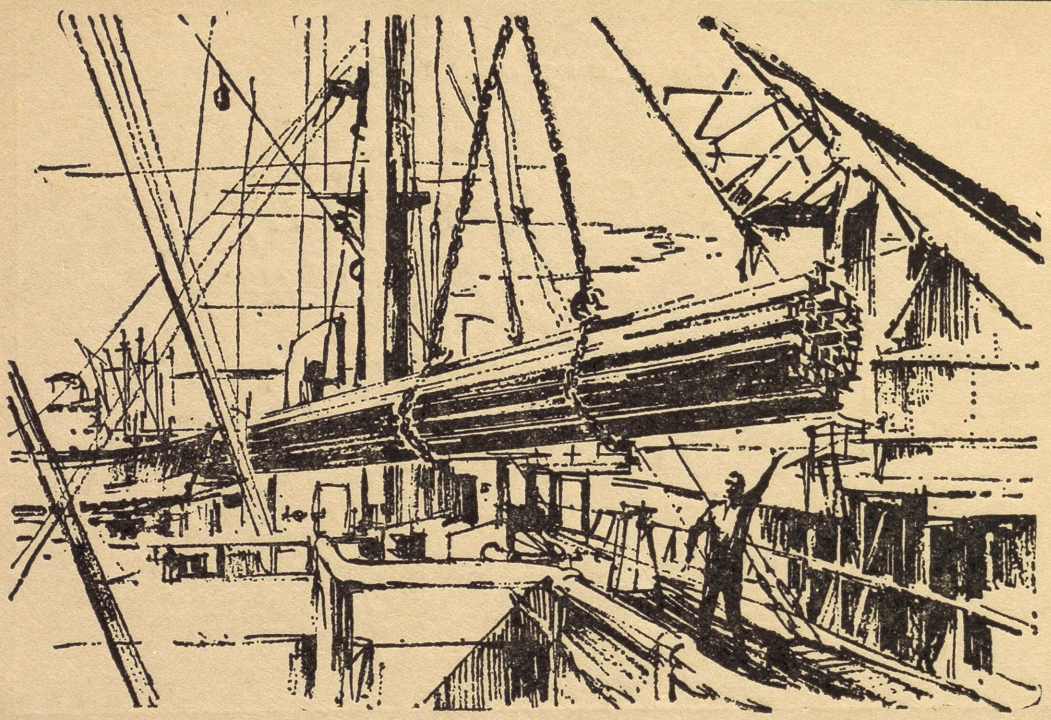

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