LIST OF IMPORTANT SPEECHES AND PAPERS BY DR.VIKRAM A.SARABHAI.

I. SPEECHES

Sr. No	Date	Place	Occasion	Subject
1.	1959	Ahmedabad	Technological Conference at ATIRA.	Role of Science in Industry.
2.	December, 1963.	Ahmedabad	Krishnan Memorial Lecture at the 8th Annual Conf. of All India Sci. Teacher's Assocn.	Where Can We Begin?
3.	December, 1964.	New Delhi	S.S.Bhatnagar Memorial Award for the year 1962.	A Dissertation - 'Probing Inter-planetary Space with Cosmic Rays'.
4.	August 4, 1965.	All India Radio	Talk Broadcast	Leadership in Science.
5.	1965	Addis Ababa	15th Pugwash Conference.	Security of Deve-loping Countries.
6.	May, 1966 (Rockfeller University)	New York	Int. Symposium on Science and Society.	Implementing Change through Science and Technology.
7.	August, 1966.	..	National Programme of Talks.	Exploration in Space - Sources of Man's knowledge.
8.	1966.	Meeting of the American Astronautical Society on 'The Impact of Space Exploration on Society'.		The Value of Space activities for Developing Countries.

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9.	January, 1967.	Ahmedabad	A'bad Management Association - Inauguration of series of lectures.	Management Plans.
10.	January, 1967.	Bombay	Renaming Ceremony	AEET as B.A.R.C.
11.	April, 1967.	Ahmedabad	IIM Convocation.	Preservation and Innovation.
12.	August, 1967.	Powai, Bombay.	IIT Convocation	Volunteers for Development.
13.	December, 1967.	New Delhi	Bhabha Memorial Lecture.	Development through Pace Setting: Horizontal and Vertical Control Systems.
14.	February, 1968.	Trivan-drum.	Dedication Ceremony.	T.E.R.L.S.
15.	August, 1968.	Madras	IIT Convocation	The Diverging Human Function.
16.	August, 1968.	Vienna	UN conference	Exploration and Peaceful uses of Outer Space.
17.	August, 1968.	Vienna	UN Conference	Summary of the Conference.
18.	September, 1968.	Vienna	12th General Conference.	I.A.E.A.

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19.	April, . 1969.	New Delhi	Lal Bahadur Shastri Memorial Lecture, IARI.	How Green is Our Revolution.
20.	October, 1969.	Ahmedabad	Gandhi Centenary Conference.	The Human Backdrop Assumptions, Experiences and Values.
21.	November 1969.	New Delhi	Society for International Development Conference.	Television for Development,
22.	December 1969.	Hyderabad	Foundation Day lecture at the Administrative Staff College.	Control and Management of Public Sector Undertakings.
23.	December 1969	Waltair	Andhra University Convocation.	Employment and Development.
24.	January 19,1970.	Tarapur	Atomic Power Project Dedication Ceremony.	Welcome Address.
25.	March 24,1970.	Bombay	National Conf. on Electronics.	Opening Remarks.
26.	August 26, 1970.	Trombay	Seminar on Pollution and Human Environment.	Talk.
27.	Sept. 22, 1970.	Vienna	14th Conference of International Atomic Energy Agency.	Speech on selection as President of 14th Conference.

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28.	October 21,1970.	New Delhi	Bhabha Memorial Lecture.	The Matrix of Development -Nuclear Medicine in the Seventies.
29.	December 29,1970.	Hyderabad	Annual Meeting of Indian Geo-physical Union.	Remote Sensing in the service of Developing Countries.
30.	February, 1971.	New Delhi	Management Convention.	Key-note Address. Management in the Changing Social Environment.
31.	August 1971.	Sinaia (Romania)	Plenary Symposium at the Pugwash Conference.	The Green Revolution.
32,	November 29,1971.	New Delhi	Inauguration of Nuclear Research Laboratory.	Remarks
33.	October 28,1971.	Jaduguda (Bihar)	Seminar on 'Current Developments in Underground Metal Mining Practices in India and Abroad'.	Inagural Address.

II. P A P E R S

Sr. No.	Date	Title	Description
1.	April 1962	Science Policy in India.	Background Paper - Talk at the Annual Meeting of the Association of Asian Studies, Boston, Mass.
2. .	July 1966	India and the Bomb.	Press Conference at Bombay on 1st June 1966 (Reprinted from Gandhi Marg).
3.	March 1967	Organisation for Developmental Tasks : Atomic Energy Commission of India.	By Kamla Chowdhry and Vikram Sarabhai.
4.	November 1967	Implications of large Atomic Power Stations as sources of low cost energy in India.	
5.	September 1968.	Nuclear Power in Developing Countries.	By Vikram Sarabhai, V.N. Meckoni and K.T.Thomas.
6.	October 1969	Science and National Goals.	
7.	January 1970.	An Agro-Industrial Complex in the Gangetic Plain.	Presented at the Seminar on Nuclear Power, Bombay. By Vikram Sarabhai, K.T. Thomas, M.P.S.Ramani, N.S.Kumra, C.M.Shah, R.K.Verma and V.B.Godse.

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8.	March 1970	INSAT - A National Satellite for Television and Telecommunications .	Presented at the National Conference on Electronics -By Vikram Sarabhai, E.V.Chitnis, B.S.Rao, P. P. Kale and K.S.Karnik.
9.	August 15, 1970.	Questionnaire from LINK answered.	
10,	November, 1970.	Science Policy of Government.	Presented at the 3rd Conference of Scientists Technologists and Educationalists, New Delhi.
11.	September, 1971.	Impact of Nuclear Technology in Developing Countries.	Presented at the 4th Geneva Conference on Peaceful Uses of Atomic Energy - By Vikram Sarabhai, K.T. Thomas, V.N.Meckoni and Kirit S.Parikh.

ROLE OF SCIENCE IN INDUSTRY*

by Vikram
A.Sarabhai

I am happy to participate today in ATIRA's first technological conference. We have for long awaited the creation of a platform for serious discussions on textile technology and of the basic sciences related to it. The Cellulose Research Committee of the CSIR organized two symposia which served this purpose partially. But I hope that this conference will undertake this task on a more satisfactory basis. This technological conference is the natural complement to the annual management conferences organised by ATIRA. The two conferences sponsored by the same research association reflect a philosophy pioneered by ATIRA and are a recognition of the close relationship of technology and the social climate within industry.

Application of the scientific method in day-to-day working I wish to speak this morning of the broad problems which confront us in the introduction of scientific and technological innovations in industry. It is hardly necessary to emphasise that today the very existence of industry depends on the speed and effectiveness with which this can be accomplished. We might temporarily insulate the economy of our country from the rest of the world, but so long as we are dependent on foreign trade for our basic requirements, this insulation would be precarious and sooner or later, our industry would have to stand or fall in competition with the industry of the

most advance countries. I would like to suggest that our success in keeping ourselves abreast of contemporary technology depends on three major factors. Firstly and basically, we have to adopt the scientific method as the basis of our operations. We require an approach which asks the question 'why and where-for' at every stage. We require to understand the underlying rational basis for processes and operations rather than work on an empirical 'hit and miss' basis. We require an understanding and the cultivation of the basic sciences of physics and of chemistry, of biology and genetics, of mathematics and statistics, which form the foundation of our technology today. In the chemical or the electronic industry, this approach is built-in, but in an industry such as textiles which has past traditions extending more than ten or twenty centuries, we find quite a different climate.

Since early times, man has used the cotton fibre for spinning yarn and for weaving cloth. But today our knowledge of the relationship of fibre properties and fibre structure to yarn qualities and the properties of the fabric which is woven from the yarn, is still beset with many mysteries. We can certainly go on spinning and weaving cloth as it was done 2,00 years

ago, but if we wish to stand in competition with other countries, we have to answer the most basic questions related to the mechanical processing of cotton. Later on, today Dr.Radhakrishnan will be addressing this conference about the relationship of structural imperfections to the strength of cotton fibres. If ATIRA has now developed

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some insight into the significance of opening in cotton processing a subject which would be discussed later by Mr.Bhaduri -or can see some light in the development of processes for the combing of short staples or can understand a little better the significance of fineness in cotton processing, these are all practical end results which are made possible not merely by empirical trials in the pilot mill, but by the thinking and ideas which have developed out of the more fundamental scientific investigations going on in the laboratories. Battling for many years with the problem of sizing, the chemists at ATIRA have now decided to examine the mechanical properties of starch films and the problem of the anti-crease cloth is now reduced to an understanding of the chemistry of resin finishes.

The history of science is full of examples which alternate from being extremely practical to being extremely basic in their approach and it is through this interaction between the basic and the empirical and practical problems that we find the greatest and most fruitful developments of modern science and technology. The whole field of what is now come to be known as operations research has a basic on mathematical and statistical theory, and the development of communication theory or the science of cybernetics, as it has come to be known, is finding applications not only in the design and theory of modern electronic computers, but in the working out

of models of physical processes. The application then of modern science and technology to industry depends on the close collaboration and communication between the technologist and the scientist.

New Administrative Practices

The second factor to which I would like to invite your attention is the inter-dependence of administrative practices and technological innovations. It is now widely appreciated that technological innovations change the content of the task of the operator, in the mechanical loom or the automatic loom, it is the machine that weaves, not the weaver, and with greater degree of mechanisation, the task of the operator becomes one of maintenance and supervision rather than of manufacturing a particular article. Thus, while this aspect has come to be accepted, I believe there is still an insufficient appreciation of a more basic change in administrative practices which is involved in many types of technological innovations. Highly efficient and automatic machines require not only close tolerances in regard to the quality of raw material, but continued long operation with unchanged conditions. The introduction of automatic looms, therefore, is a feature which for its success depends on effective maintenance of standard yarn quality which is, again, dependent on the effective maintenance of the quality of the initial raw material which is cotton, which is purchased and fed into the mills.

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Thus, the introduction of the automatic loom imposes new standards for the purchase of cotton and for the maintenance of the spinning department. If, for instance, yarn quality suffers through the imperfect training of workers or the use of many badli or temporary workers in the spinning department, the implications of the new technological innovation have to be faced in the personnel policies of the company. Moreover, the method of production planning and scheduling and of the time span for which production remains constant, require drastic modification as soon as one goes to more automated machines. The technologist knows that if he could be given conditions under which he could set machines and operate them without changes for a sufficient length of time, he could improve greatly the quality and cost of goods but the traditional administrative practices with regard to sales and distribution in the Indian textile industry are such that any long term planning of production so that the sorts remain unchanged, is unheard of in a majority of mills.

I have discussed this problem at some length merely to illustrate that a technological innovation such as the introduction of really expensive high quality looms is a feature which suceeds only when it is undertaken in the context of changed administrative practices from those which could succeed in an older level of technology.

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Proper Organisational Structure

The third factor to which I would like to draw your attention is the question of organisational structure which will make possible the new administrative practices. The need to specialise to keep abreast of contemporary progress in science and technology has made it necessary to develop differentiated functions and a well defined organisation involving line and staff relationships. In this structure, the technologist charged with the task of production is not the know-all of all that is required to discharge his function adequately and consulting staff within the company or a group of scientists outside involves an acceptance of failure in the sense that Kenneth Rice indicated to us at the last management conference. This is possible if this does not constitute a threat to the individual concerned. These social aspects of technological innovation have been the central theme of a number of the management conferences organised by ATIRA and, in my opinion, are no less crucial than the new technology which many of our audience today have witnessed at the Milan Fair.

Having thus discussed the broader questions of the introduction of technological innovations and science in industry, I might turn to an examination of the situation of which we are most familiar. ATIRA. has now been in existence for almost ten years. Through six of these years, I had the privilege of being associated closely with its day to day

working and in the later years, as a member of its Council and of the Research Advisory Committee. Having thus watched it grow from small beginnings to its present position, I might be forgiven if I end this talk today with an examination of how far we have succeeded in Ahmedabad the introduction of science in industry.

Relationship of Research Associations with Government

The objectives of ATIRA are wide and all embracing as regards the service which it can render to industry. When at the start consideration was being given to the organisational structure of the Association and its relationship to Government and to industry, it was felt that the most appropriate structure for us to follow was that of the British cooperative research associations which are admirably suited to serve the needs of a large number of small units. Research associations involve the government adopting a supportive role and the industry taking on the major responsibility for cooperative backing and participation of those who work in industry. During its first five years of existence, ATIRA's relationship with government was in conformity with this basic pattern. But in the more recent past, the relationship with Government has become nebulous with a series of encroachments on the autonomy of the research associations engendering the climate in which responsibility can hardly be shouldered effectively by the research associations. One can hardly inflict more calculated damage

to the concept of research associations than by some of the perhaps well-intentioned policies of control and supervision and coordination from the top which are being mooted at the present time.

Relationship with Industry

ATIRA's relationship with industry has grown through the years in maturity and in understanding, Initially, in spite of good top management support to ATIRA, there was in general a feeling of apprehension and suspicion amongst technicians, but during the last five years, there has been a very close collaboration between the technicians in industry and ATIRA, and I am perhaps right in saying that much of the suspicion has now given way to more positive feelings. However, there is insufficient participation today of top management in the functioning of ATIRA. The problem is complicated and my own feeling is that status problems in meetings and in liaison are playing an important role. In a large number of units, social and organisational factors are undoubtedly acting as a hindrance to the application of scientific and technological innovations.

Indian efforts towards Industrial Research still insufficient

I doubt if anyone would deny that management should base its decisions and policy on facts meaningfully obtained. However, we find that today only a third to one half of the units in Ahmedabad have regular programmes of obtaining meaningful statistics through Quality Control staff or through Quality

Control functions performed by line staff. The situation with regard to chemical laboratories for the testing of raw materials is almost similar. Modern systems of cost accounting which should form the basis of contemporary management are even rarer. This is not a question of lack of know-how or lack of knowledge that the investment would pay off, for there is the significant fact that in thirteen out of the sixty Ahmedabad mills which made a profit of more than Rs. ten lakhs per annum in the year 1957, there are in *95%* of the cases Quality Control departments in addition to laboratories. I hope, I am not conveying that I believe the establishment of the two facilities that I have named are themselves responsible for the profitability of the thirteen mills in question; but it is significant that the adoption of proper and contemporary administrative procedures which are considered necessary for the application of scientific and technological innovations are associated with the most successful units in this town. As against the 95% utilisation by these units of the facilities, only 30% of the remaining have similar provision. If the so-called weaker units of the industry are to survive the challenge, it is important that before it is too late, the social and organisational climate within these organisations is modified and undergoes a change which would permit a more easy introduction of scientific and technological innovations on which the industry would stand on a firm competitive basis.

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Lastly, in discussing the relationship with industry, I feel it right to emphasise that the effort that we are now devoting in cooperative research, large as it is compared to standards in this country, is nevertheless insufficient in relation to the effort which is directed by competing industry in other parts of the world.

Coming to factors within ATIRA, there is today a most impressive programme of basic research and of technological applications. There seems, however, an ever present need to emphasise the necessity of greater integration of social and operational studies with the technological studies made at ATIRA. With increasing maturity and stature of the active research worker at ATIRA, there is a growing tendency towards consultancy and this has raised a fresh problem related to salary scales within industry as compared to those in the research association. I am one who believes that a differential between the two will exist, but this has to be within certain limits and the present basis on which comparison of salary scales in ATIRA is made with other research associations, academic bodies and national laboratories rather than industry would soon be untenable.

And lastly, I would make a plea for the widening of the experimental field of ATIRA by the ever increasing use of units in industry where scientific methodology and thinking is present as one vast field laboratory. I believe we can derive

satisfaction from the contribution that has been made here in the application of science to industry, but at this stage, we have new problems to face, both internal and external, within units and in the research association which we have created. Let us apply our minds to the examination of what has happened and where we should go and evolve a clear cut operational plan which will carry further and more effectively the task which we have only begun.

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* Lecture delivered at the Technological Conference 1959 held at ATIRA, Ahmedabad-9.

WHERE CAN WE BEGIN ?

by Dr. Vikram A. Sarabhai

(Krishnan Memorial Lecture delivered at the 8th Annual Conference of All India Science Teacher's Association held at Ahmedabad in December 1963.)

I met Dr. K.S.Krishnan in Madras in 1940 and had, the privilege of his friendship for almost twenty years, till his death. I am therefore particularly grateful to the organisers of this Conference to have invited me to deliver the Krishnan Memorial Lecture and, through this, to pay homage to a great physicist and a great man.

Krishnan's interests and knowledge extended from Physics to Music and the Upanishads, to literature in English and Sanskrit and in Tamil. There are some equally clever scientists today, but few who can match his wisdom and modesty. It was, therefore, a rich a rewarding experience to come in contact with him,

Krishnan and I worked together on several bodies dealing with education and scientific research. looking back to the meetings and the many private discussions which we had, I now marvel at the patience and the courtesy which Krishnan showed to an young and not so wise person who at that time held strong views on many questions of policy and organisation. In a panel of the Planning Commission or in the Council of. Scientific and Industrial. Research, we often considered how the standards of education and research could be improved in this country. We could readily identify the troubles we were facing, but when it come to the operative part of what we could do in the future, there was in those days a considerable difference of emphasis between Krishnan and myself. While we both agreed, that the quality of the men who work a project has a determining influence, I continually emphasized that certain organisational factors had to be appropriate for men to work satisfactorily. Krishnan would reply that any organisation or procedure can be perverted by those who wish to do so, And so we would go on.

Lot me give an example drawn from the Council of Scientific Industrial Research. Over a long period of years, the Council has supported literally hundreds of research schemes in universities and in research establishments. The majority of these involve petty grants of three to four thousand rupees each. If the question is put as to how far these research schemes have directly contributed to the industrial advancement of the country or to a better understanding of the basic sciences, we must indeed fool quite disappointed with the answer. On the other hand, the schemes have of course an important training component built into them since they provide a stipend for graduates to undertake

training in research methodology. Research schemes were at one time not differentiated in relation to the basic objective which was sought to be achieved and I advocated that this should be done. *I* felt that clarity of objective would make the scheme more effective. Moreover, I suggested that rather than a scheme be considered and approved or rejected only *run* the basis of a proposal sent in writing, there be a face to face presentation by the investigator-in-charge appearing before his peers who are called upon to consider the proposal and to evaluate its progress, Krishnan repeatedly pointed out to me in private conversation that I was suggesting artifices which by themselves would not change matters, that the crucial question was the manner in which the individuals in the committees and those who were investigating approached their respective tasks. After some discussion within the C.S.I.R., the proposal to clarify objectives of schemes in terms of their primary function of training, or research in a basic science or in an applied field was generally accepted. However, subsequent events proved that what Krishnan was emphasising was very pertinent indeed and there was little visible change in what really wont on. The schemes continued to help train scientists, but produced little basic or applied research of real value. It was clear that if one creates structures and procedures but the organisation is not manned by people, who accept the basic assumptions and who are motivated to promote those assumptions, we can frustrate the high ideals with which we start,

I can give a second example relating to universities. Most people today arc very concerned with the performance of our educational institutions in imparting understanding and skills to our young men and women. We know of many exceptions, but these are largly related to factors extraneous to the educational system. One's, mind then immediately turns to the way our universities are constituted. The University Grants Commission which is to safeguard standards of university education is currently preparing a model constitution of a university. But let us examine this approach more closely. We have in our midst some universities which are mainly affiliating and others which are-unitary in character. Wo have those which are residential and others which provide contact only during a few hours of the day. There are universities whose structures are such as would provide a maximum exercise of authority and control by the academic staff and there are others in which the academic voice is smothered by the large representation given to outside elements. And in each class of institutions there are those that do a fair job and others which make an appalling mess of the task which is entrusted to them. The moral of the story then is that almost any institution can be perverted. Organisational factors by themselves cannot take us forward; but that it is a combination of organisation with the quality of the people involved which can ultimately produce results which we all desire.

At this point, one may well suggest that one should create an appropriate organisation and an appropriate technique for selecting people and that we would then have a solid foundation to build our projects for the future. We run into the same difficulty here again,

Let me illustrate with an example At the Gujarat University the appointment of staff below the level of Readers is made by a Selection Committee consisting of the whole Syndicate of 19 members. Interviews are held over a period of two to throe hours when sometimes as many as 6 to 10 Candidates may be called for interview. Why has such an unusual procedure been adopted in which those who are competent to judge the academic merits of the individuals concerned are either absent or in a complete minority? How is it appropriate to have 19 members sitting.in one group interview an individual? Could it be that the members would not trust the impartiality with which the appointments would be made by a smaller group? Selection itself can therefore be perverted.

There is therefore no real escape from the situation as long as we continue to believe that thirds can be improved by supervision of one tier over another, instead of from the self-motivated initiative of dedicated individuals and groups, What wo need is not more control from the top, but a structure within which individual and group initiative can be supported; not to impose conformity, because we have neither the sanctions nor the traditions to effectively impose such conformity, but to recognise the diversity of approaches which can all lead to a successful completion of our task.

People will f'dSSt out that if indeed we were to leave initiative to local groups and individuals, what would prevent the emergence of bogus organisations and of charlatans, who would once again exploit the situation? The answer to this is that one really cannot prevent this happening, but if in the process we permit the serious minded individuals to work according to their own conscience and according to. their own way of thinking, then the cause of education will bo advanced. I believe that the paralysis in education, inspite of the widespread discontent with the present situation and the many learned reports of distinguished committees arises from the freezing of initiative at the teaching level through regimentation, controls and well intentioned supervision. More latitude to initiative in the class room and more freedom to institutions inevitably imply compact centres of learning rather than Empire building universities or school authorities with exclusive privileges and territorial jurisdiction to impose a particular educational approach and methods. To adopt this course requires faith in the view that standards will be promoted by institutions performing their role in society on the strength of their individual image without shelter of a formal myth of quality through affiliation to coordinating bodies such as a University or the U.G.C.

What wo have seen in general terms for education and research applies of course to the particular problem of science education with which this conference is most concerned. Hero too development will depend on the initiative of individual teachers and students, as well as groups of teachers and groups of students. An indication of what is possible through such initiative can be had from an experiment which is currently being started at Ahmedabad for the improvement of science education.

4 The basic

assumptions underlying the project arc :-

1. that inspite of the known weaknesses of the existing educational system such as unfavourable teacher-student, ratio, lack of integrated education at different levels, prevalent emphasis on results of examinations, the nature of the evaluation system, the low level of emoluments of teachers, it is possible to give more valid education than is currently prevalent.

2. that much can be achieved by the initiative of institutions, teachers and students.

3 . that organisational changes on a vide scale would follow efforts on an informal cooperative basis in small active groups.

4, that long term improvement requires consistent effort over a period of time and ad-hoc seminars by themselves are not sufficient,

5. that valid experiment for improvement in science education must be related to an evaluation of the programme through feed back from the students in respect of the change that is produced.

6, that a cooperative programme to succeed must involve voluntary commitment on the part of motivated groups of teachers and students and of organisations taking part in the experiment.

7. that assistance from outside is most advantageous when such commitment has already been made.

A group of teachers drawn from High Schools, Colleges and research institutions attend meetings to discuss for each course :

1* The fundamental concepts involved, which are essential for the students,

2. How much of the teaching can bo done through observations and experiments which can be carried out by each student, and which of them should be demonstrated by the teacher,

3. Quantitative aspect involved,

4. Various typos of new problems, which will involve the application, by the students concerned, of the principles and fundamental concepts*

The teachers then attempt to apply, during their course work, in the following weeks the techniques which may arise during the discussions and report back to the Group their experiences with regard to the same, Efforts are being made here to assist the teacher in the school by providing locally made experimental kits and facilities for demonstration of filter on a regular basis.

There is also a programme for gifted students studying in Higher Secondary classes, Pre-University and F.Y. B.Sc, classes, who have volunteered to spend three hours weekly. Initially, work is confined to Physics using primarily the material developed by the Physical Science Study Committee in the United States, Reading material from, the text is suggested and during the period that they spend at the Physical Research Laboratory, the material is discussed, selected films screened and important experiments performed by the students,

A parallel project is being undertaken for the improvement of teaching of Algebra at the High School level. Here too, self-motivated action by a group of teachers has load, to a presentation of their, recommendations to a wider group and, within the next few months, they are hopeful of direct application in the classroom.

The project which tries to bring together the teachers and research workers in this area who have a desire to do something actively to improve science education has a specific objective to be achieved on a measurable period of tine. Moreover, the project is capable to evaluation. The Work will be sustained over an extended period of time, rather than through one or two meetings or seminars separated by a long time interval. The project will enable us and such other groups all over the country to decide the ways and means and the long term approach and methodology for the improvement of science education.

The last ten years has witnessed a tremendous recognition by groups in different parts of the world of the need to, question the objectives, the content and the methods of education. Interested individuals and groups can benefit a great deal by contact with the work of other groups in this country and abroad, Even if it may take a long time before we can establish nationally a project as basic as the projects initiated by the National Science Foundation in the United States in the fields of Mathematics, Physics, Chemistry and Biology, we have much valuable material from the U.S.A. and from other countries which is available for discussion and adaptation by our science teachers. The activities of N.C.E.R.T. and the U.G.C. in recent years in conducting Summer Schools to familiarise teachers with the developments abroad has of course been moat valuable. But the full effectiveness of our national programme in this direction depends on the following factors which have to be explicitly recognised.

1. The State Education Departments and Universities have to permit the adoption of never techniques of teaching, evaluation and the recognised course content by individual schools and colleges,

2* The Institutions concerned have to make a commitment to implement the newer techniques through encouragement to teachers, through acquisition of equipment and through a modification of the evaluation system.

I hope that the participation of teachers in the next series of Summer Schools to be organised during 1964, would lead to the effective implementation on an experimental scale of the new courses in several institutions. The activity undertaken at the Centre in bringing our inexpensive Indian editions of standard literature and text-book must have great impact in the years to come. The P.S.S.C. text-book in Physics, is a part of a total programme which involves teacher's Resource Books, Laboratory Manuals, Laboratory Kits, Motion Pictures and Evaluation Papers. The whole purpose of the project gets defeated if aftern having gone through a Summer School a teacher is left to introduce the new course holding only the text book in his hand. The purpose would also be defeated if, for instance, only one Laboratory kit is supplied to each school and the teacher starts demonstrating an experiment rather than the student doing experiment for himself. Thus those projects have to be implemented in a total way if we wish to give them a serious trial. I am hoping that the U.G.G. and the N.C.E.R.T. will together keep this in mind and accept the responsibility of making available the whole package to our teachers and to our educational institutions before the commencement of the next academic year in June 1964.

One of the basic things to which I wish to draw attention for the improvement of science education is knowledge of mathematics. Neglect of mathematics which now occupies a crucial position as the language of science, by those who wish to 30 in for a career in science, must lead to the results. In the context of divergent opinions as to the role of mathematics in general education, it would be impossible to insist that mathematics be taught to all High School students. Wo therefore need to require that only those who have done mathematics can gain admission to university courses in science, engineering or medicine. Better still, we should have a separate entrance examination to select those who wish to specialise in science at the university level.

In conclusion, I wish to highlight the need for a totally different approach by the Centre and the States towards education. This calls for support to local groups of educationists planning their affairs according to their own experience. It calls for an organisation that recognises diversity and the role of individual initiative. It believes that ultimately it is the teacher who puts life into education, a theme emphasized so-much by Krishnan,

*PROBING INTERPLANETARY SPACE WITH COSMIC RAYS

by
VIKRAM A. SARABHAI

The *sun.* is the driving force of weather and of all. life on earth. It has been perceived by man through the ages as one of the most constant objects of nature. Against this constancy man has found it difficult to understand the changing environment on earth, years of drought and floods, hurricanes and storms. He has invoked the divine to reconcile himself to the caprices of nature. But to the scientist, there are clearly many missing links in our understanding of the relationship between the sun and the earth. He may have fathomed quite early some of these, were he not tied for long to the *&%$$?£* earth under the blanket of the atmosphere which provides a window admitting only a narrow band of the radiation from the sun which brings energy to the earth. It so happens that the sunlight which he normally perceives is remarkably constant.

We know that the bright sphere which we observe as the sun is itself enveloped by its corona at a temperature of more than a million degrees. This is normally invisible except when the bright disc is eclipsed by the moon or when

*A dissertation presented in 1964 on the occasion of the S.S.Bhatnagar Memorial Award for the year 1962.

viewed through special instruments, Apart from visible light, the sun emits electromagnetic radiation in the form of radio waves, infra-red radiation, ultra violet radiation and X-rays and we know, moreover, that the corona continuously expands producing a solar wind which fills interplanetary-space with rarefield plasma consisting mostly of protons and electrons. Observed closely in filtered light, the sun's disc has a fascinating micro structure of bright and grey areas and of filaments. Complex patterns of local magnetic fields are often associated with this structure. The frequency of dark sunspots and other symptoms of local activity change over a period of about 11 years with the solar cycle; and so does the intensity of a significant part of the solar radiation coming to the earth, particularly of some components outside the visible region. Occasionally there is a catastrophic event involving a bright flash of light observed on the disc. These flares are followed by the emission of a burst of fast particles with energy millions of times greater than the highest energy of radiation from natural radioactive sources. Perhaps one reason for the slow progress of our understanding of sun-earth relationships is because we exist on the thin surface shell of the earth with very special conditions -of temperature and density, where there is little effect of electro dynamic forces on fluid motion. But conditions in the interior of the earth, the outer atmosphere, interplanetary and interstellar space and in stars are such that electromagnetism,

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and hydrodynamics are intimately linked with each other. While we have come to recognise the crucial importance of hydromagnetics in astrophysical problems, much experimental and theoretical work requires to be dome before we can hope to have a better understanding of how nature functions on a cosmical scale. Interplanetary space, where a plasma wind from the sun stretches out with it a frozen magnetic field, is a wonderful laboratory for this kind of studies. We do not yet know how to duplicate these conditions for controlled experimentation.

Space-craft travelling at great distances from the earth directly sample plasma and magnetic fields and measure those components of solar radiation which are normally blanketed by the atmosphere. Such studies provide valuable information on the microstructure of conditions in interplanetary space. Observations of comet tails and the disturbances produced, in the earth's magnetic field by plasma from the sun provide indirect information of plasma conditions on a larger scale. There is, however, yet another indirect method which furnishes unique information over an even larger region of space in the solar system, extending to several million kilometres from the earth. This is by using cosmic rays as probes for studying interplanetary electromagnetic conditions.

Cosmic rays were discovered almost half a century ago, but theories concerning their origin in the universe are still

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largely speculative. We know that much of the radiation consists of very energetic protons and a smaller proportion of heavier nuclei, which have originated mainly in our own galaxy and have, on the average, spent about 2.5 million years in interstellar space. The energies of individual particles are truly staggering, sometimes exceeding a billion times what we can currently achieve in our most energetic particle accelerators, which itself is more than a thousand times the energy found in natural radioactivity. Through interaction with magnetic fields in interstellar space, the cosmic rays which approach the solar system are almost completely isotropic and have lost all -sense of their original direction. Thus they appear to come with equal intensity from all directions. However, within- the solar system they encounter magnetic fields associated with plasma from the sun. In consequences, they lose their isotropy and undergo significant changes in energy and total number density.

For the past twenty years, I have been interested in studying the minute changes, often as small as a few parts in a thousand, which are observed in the intensity of galactic cosmic rays on earth due to the modulation that occurs within the solar system. Our group at the Physical Research Laboratory, Ahmedabad, operates instruments which continuously monitor cosmic ray intensity at Ahmedabad, Trivandrum, Kodaikanal and Gulmarg

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in India and. at the Laboratory at Chacaltaya in Bolivia, which is at an elevation of 5200 metres above sea level, very close to the geomagnetic equator passing through South America. I have also been actively connected with a very high counting rate instrument at the Massachusetts Institute of Technology. We are particularly fortunate to work near the equator where we observe changes in cosmic rays arriving along the plane of the ecliptic which contains the sun and the earth. The systematic character of daily meteorological changes in the tropics has moreover enabled us to disentangle effects due to changes within the atmosphere from those in interplanetary space. We observed fairly early that, with respect to the sun, galactic cosmic rays were not arriving uniformly from all directions. Indeed the daily variation of cosmic rays, corrected for meteorological effects, was demonstrated to be due to the anisotropy, of galactic cosmic rays as it is scanned by an instrument fixed to the spinning earth. Almost ten years ago we were able to show that the anisotrony itself changed with the 11-year and the 22-year cycle of solar activity. We noted that conditions in inter-planetary space altered from day to day almost like weather on the surface of the earth, and while one could sometimes talk of average conditions over an extended period of time, it was indeed necessary to study the phenomena with accuracy on a day-to-day basis in order to understand the physical processes that were operative.

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It is difficult to describe in detail the insights which we have gained in our study of solar activity and the physics of interplanetary space without involving terms which only the specialist may be expected to be familiar with. I - think I will spare mutual embarrassment by presenting at this time only a general description of the area in which I work and of its broad significance to scientific knowledge. Like any other field of modern science, insight into the nature of cosmic ray variations has grown through work by many groups in the world - in Europe, in Asia, in Australia and. in the Americas. The particular contribution to this international endeavour of our group at the Physical Research Laboratory, Ahmedabad, has been in identifying the electromagnetic states of interplanetary space in terms of measurements made with galactic cosmic rays and disturbances in the geomagnetic field. We feel that it is important in studying the solar anisotropy of cosmic rays to look at the direction in which there is an excess as well as the direction in which there is an apparent deficiency of intensity. This permits us to observe the effects of advancing magnetic field discontinuities travelling in interplanetary space, sometimes from the sun outwards, but more often appearing to corotate with the spinning sun. We have recently demonstrated that, during the period of low solar activity early in 1964, there was a deficiency of cosmic rays from a direction towards the

sun along the frozen magnetic field, stretched out by the plasma wind. We believe that we are observing here a mechanism whereby galactic cosmic rays penetrating into the solar system along the magnetic lines get scattered by the field irregularities near the sun.

Last year, I proposed that local regions of excitation in the solar corona as shown by the varying intensity of the green coronal emission line should imply a non-uniform velocity of solar plasma wind from different regions of the sun. As the sun spins on its own axis, the non-uniformity of wind velocity should have certain broad implications to plasma conditions in interplanetary space. There should be regions where fast plasma blows behind slow plasma and creates shock transitions and turbulent conditions. There should also be regions where slow plasma follows fast and in consequence, cavities which have low densities and low magnetic fields should be produced. As the earth enters various structures in interplanetary space due to the non-uniformity of solar wind-velocity, it should, experience characteristic geomagnetic disturbances and cosmic ray effects. The model offers a plausible mechanism for the 27 day recurrent effects seen in geomagnetism and cosmic ray variations. Moreover, it suggests a mechanism in which cosmic ray intensity may be depressed for several days as in some long-lasting Forbush decreases and an explanation for geomagnetic disturbances which are sometimes associated with decreases and at other

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times with increases of galactic cosmic ray intensity.

We have recently verified some of the predictions of the model of interplanetary conditions on the basis of a non-uniformity of solar wind velocity with ground-based observations and studies in spacecraft. An analysis of the anisotropy in interplanetary space from 1958, when the sun was at its height of activity, to 1963, when the sun was relatively quiet, has demonstrated the progressive change of the type of modulation which occurs with changing con-, ditions in interplanetary space. We are far from having solved the jigsaw puzzle, but we recognise that in doing so we shall have to pool theoretical predictions and model building, experimental observations of solar activity and measurements made in spacecraft as well as observations of the variations of cosmic rays and of the geomagnetic field. From an analysis of ground-based megnet meter measurements of fluctuations of the strength of the earth's magnetic field following magnetic storms, we have, for instance, estimated the dimensions of the irregularities in plasma wind which correspond fairly closely to estimates made from other considerations.

I am deeply grateful for the honour done in the recog-

nition of my modest contribution through the Shanti Swarup Bhatnagar Memorial Award. I have had the privilege of having work with me, initially as doctoral students and then as colleagues, a series of eager and duplicated young men with originality, who have shared the excitement of discovery with me. The story which *I* have related today is their story as well. For those who are interested in the detailed scientific aspect of our work, I list what I believe to be some of our most significant published contributions.

Shri Jawaharlal Nehru will be remembered as a head of a State in the atomic age who recognised, perhaps more than any other statesman, the importance of science to modern society. I wish to take this opportunity to pay my respectful homage for all that Panditji did to encourage many, such as me, in our effort to pursue science.

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LEADERSHIP IN SCIENCE

By

Vikram A. Sarabhai (Talk broadcast by All India Radio on 4 August 1965)

1. Clearly the development of a nation is intimately linked with the understanding and application of science and technology by its people. It has sometimes been argued that the application of technology by itself can contribute to growth. This is certainly true as an abstract proposition, but fails in practice. Witness the state of development and social structure of countries of the. Middle East, where for decades resources of oil have been exploited with the most sophisticated technology. History has demonstrated that the real social and economic fruits of technology go to those who apply them through understanding. Therefore a significant number of citizens of every developing country must understand the ways of modern science and of the technology that flows from it.2. An ability to question basic assumptions in any" situation is fostered by probing the frontiers of science, whatever field one may be engaged in, whether it is Biology, Genetics, Atomic Science or Space Research. It is this ability rather than an empirical hit and miss approach which proves most effective in tackling the day to day problems of the world. It follows from this that countries have to provide facilities for its nationals to do front rank research within the resources which are available. It is equally necessary, having produced the men who can do research, to organise task oriented projects for the nation's practical problems.

3. One of the inevitable consequences of the introduction of modern technology is a gradual erosion of existing values - a drift towards a man-centred world substituting another in which man is only one element in all of nature. What can replace ethics born out of a religion and a faith which no longer holds us? You may be surprised to hear me talk of faith. It implies on my part primarily a recognition that an individual does not exist in isolation. Almost any action that he takes affects the outside world and he has to be aware of how the outside world is likely to react to his action. In other words, he has to have faith and confidence in the type of reaction which he may expect before he can take even the smallest action. If he has to cross the street, he must have faith that the driver of a motor car understands the high-way code.

It seems to me that a broad understanding of the physical and social environment in which man lives is the most urgent task which faces all humanity. When we come to think of it, lack of insight concerning the environment in which man operates has posed a problem at all times. Just as superstition took hold of an unenlightened man who received solace from religion, so can prejudice and a feeling of omnipotence permeate the minds of those who, without bothering to understand science, enjoy the rich rewards flowing from the application of technology. When gimmicks substitute magic, we have produced no essential change in the enlightenment of the total sociopolitical system. On the other hand, today, the consequences of failure to raise the level of enlightenment are more serious to the security of the world than they were ever before. The task of promoting an understanding of science is of course at the core of the problem of education and becomes increasingly more difficult in the context of a population explosion. Acquisition of technology by itself does not contribute to this understanding. One is forced to the regretful conclusion that no society has tackled this problem effectively.

Hinduism has a substratum of philosophy which is fascinating to the modern scientist. The life of the common man reflects many of the values related to this philosophy, unconsciously imbibed through literature, the arts and social traditions. We recognise that perception involves the outside object as well as the observer. We appreciate the subjective character of personal experience. We accept that there are a thousand paths to enlightenment. In relativity we learn of the importance of the frame of reference of the observer and how the results of observation defend on the relative state of his frame with respect to that which he observes. Absolute right and wrong do not exist in the values of those who have understood the Upanishads or those who have followed the concepts of relativity.

When I talk of the scientist in this vein, it is perhaps necessary to point out that *I* distinguish between one, who has merely gone through a formalistic training in science, from another, whose scientific experience is reflected in his personal values. I think the discussion is meaningful only in regard to the latter.

4. I can illustrate my point concerning science and human values by citing an example which is related to the implications of science and technology to modern war-fare and how these affect national sovereignty. As soon as hydrogen

bombs could be delivered with Inter-Continental Ballistic Missiles, capable of hitting a target to an accuracy of a few miles at a distance of six to eight thousand miles, the implications of a war between adversaries possessing such weapons were too grave for any one to contemplate armed conflict as a means of solving international disputes. If co-existence between nations formed a part of the "Panch Sheel" adopted by Asians from Buddhism, it was also advocated by Premier Khrushchev from an appraisal of the consequences of the balance of terror that exists between the East and the West.

At all times social change has been related to technological developments and in each era, new constraints, social and political, are imposed on those who partake of the change. Just as an individual who chooses to live in a community voluntarily renounces the right of throwing a stone anywhere he pleases, which he undoubtedly could exercise in the jungle, so in the atomic age, nations are forced to accept a self discipline where the freedom of. settling disputes through the use of force on a grand scale is no longer meaningful. But if there are disputes between nations, how are they to be settled? Recourse to negotiations or, if necessary, arbitration through a third party or reference to an outside tribunal are the only courses open to us. The provisions of the United Nations Charter referring to collective security imply an implicit acceptance of this. The leaders of the nations who founded the world organisation appreciated what sovereign states could no longer do. These provisions, like many others, have never been effectively implemented. The. security of the world and the political settlement of international disputes would be very much assisted if the common man of all nations understood the constraints of the environment in which he lives. In the context of an otherwise bleak international situation, the recent settlement negotiated by our Government on the Kutch border issue stands out as a most positive contribution to world peace. In the , sniping that has followed from some quarters, we have a remarkable demonstration of the problems of a society which loses faith in Panch Sheel and has not yet accepted the ethics growing from modern science.

Perhaps by now, you have realised that *I* am beating about the bush, that I have not talked about leadership in Science. You are right; but I am afraid this fairly long preamble on the significance of science is necessary before I can come to the point. I suggest that we consider

leadership in science to achieve the following: First, to foster creativity and an interest in getting to the core of problems, relegating for the moment an empirical approach. Secondly, to provide experience on a wide scale, whereby men can understand the back-drop in front of which he operates and can evolve values and ethics consistent with the real constraints imposed by his environment. Thirdly, to provide the application of science and scientists to the diverse practical tasks of society, that of building the economy, of creating a desirable social environment and to problems of fields such as national policy, security and defence.

Leadership for the development of creative disciplined individuals, highly motivated to ask basic questions, is not leadership of the type that we normally understand. There is no leader and there are no led. A leader, if one chooses, to identify one, has to be a cultivator rather than *a* manufacturer. He has to provide the soil and the overall climate and the environment in which the seed can grow. One wants permissive individuals who do not have a compelling need to reassure themselves that they are leaders through issuing instructions to others; rather they set an example through their own creativity, love of nature and dedication to what one may call the "Scientific method". These are. the leaders we heed in the field of education and research. It is they who continually challenge existing assumptions on the objectives and methods of education, who concern themselves with providing experiences from which individuals build values and frames of reference, realising the subjective character of perception.,

When we come to the application of science to the real tasks of a nation, it is again the inter-active type, of leader, rather than a boss, who is most effective. He is required to relate himself to the work of others, to give as well as to receive. In our society, scientists encounter a curious difficulty in accomplishing useful tangible results. We place intellectual endeavour on a very high social scale, but believe that those who are engaged in it are unfaithful if they should be interested and concerned with day to day practical affairs including their own standard of life and personal security. We look down on our research scientists in national laboratories or our academics in universities, if they engage themselves in outside consultation or if they choose to augment their income from task-oriented projects of a practical nature. We implicitly promote the ivory tower, the alienation of the persons of insight, from those who do things. As I have

said earlier in this talk, I believe that those who can pose basic questions are the ones who can best do applied work. For, in most things, locating the real problem goes a long way towards its solution.

To create conditions for the application of science and scientists to the real problems of society, we have to encourage scientists to interest themselves in problems outside their fields of specialisation. Sure enough, one does not expect to give to the opinion of a scientist special weight in fields other than his own. But a person who has imbibed the ways of science injects into a situation a new way of looking at it, hopefully perhaps, a degree of enlightenment with regard to the approach to problems and thus provides leadership which is very valuable. I am here not talking about getting scientists into diverse committees. We have plenty of it. I do advocate that we make it possible for them to work in their own fields of specialisation in addition to undertake or collaborate in specific jobs. There are innumerable situations where this is possible at the doorstep of every individual. These could arise in improving curricula and methods of education, in setting up local industry or promoting the productivity of farms, in local and regional planning, in implementing programmes for population control or community development. In Ahmedabad, for instance was started two years ago a Group for the Improvement of Science Education. This Group consists of teachers drawn from schools, colleges and research institutions and some gifted students from these institutions. What brings them together is a strong personal motivation to improve understanding of science and the standard of education. They are ready to question, to innovate and to share experiences. At each level, wherever they work, they provide the type of leadership which we are considering here.

Through experience we know that conditions of work in India within our own specialised scientific fields rarely match the facilities available in several other countries. Some of us get frustrated striving against heavy odds. Others leave the country. But those that can apply their insights to the problems of the community and of the nation discover an exciting area of activity where effort is rewarding even while the results come slowly.

What should we do to provide opportunity for such leadership? I do not expect attitudes which segregate scientists and intellectuals from the real world to change quickly, I do

not believe that in the near future we are likely to provide to scientists and educationists job opportunities and service conditions which are on par with those enjoyed by administrators. But I have a dream, a fantasy may be, that we can provide encouragement to those who will accept responsibilities for real tasks, big and small, even while they continue to do their own work. Moreover that we can secure acceptance of the notion that such task oriented activity, seriously undertaken and with a well defined objective to be realised in a given period, should receive financial reward which will ameliorate the total situation in at least one important aspect. Leadership in science may then arise out of a new climate for growth.

REPRINTED FROM

SCIENCE AND THE HUMAN CONDITION IN

INDIA AND PAKISTAN

THE ROCKEFELLER UNIVERSITY PRESS, 1968

SECURITY OF DEVELOPING COUNTRIES

by

Vikram A. Sarabhai

I wish here to consider the security of the large number of developing countries which are not members of one of the military alliances related to the super powers. I exclude the rather special problems of developing countries whose security is safeguarded through their membership of military alliances with economically advanced nations.

1. The changing pattern of international relations

In international relations, the political, economic and military interests of nation often pull in diverse directions. Yet, during the fifties, the world at least on the surface presented a relatively unambiguous division of countries into three groups. As long as the great powers were preoccupied with problems of security arising from the East-West conflict and the developing nations were largely concerned with problems of attaining independence and national identity, the center of stage was occupied by two military blocks antagonistic to each other with a third group of non-aligned nations largely made up of developing newly independent countries in the wings. “Non-alignment” almost came to be recognized as describing the political status of a nation, like neutrality, rather than the position of a country on an individual issue. This image o the “non-alignment” nation persisted even though Nehru*, in 1947, in the Constituent

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* Extracts from Jawaharlal Nehru’s Speeches, Vol.1, 1946-49.

Assembly of India, said:-

> "We have proclaimed during this past year that we will not attach ourselves to any particular group. That has nothing to do with neutrality or passivity or anything else.
>
> "We are not going to join a war if we can help it, and we are going to join the side which is to our interest when the time comes to make the choice".

It is only in the present decade that we find increasing recognition of a real structure of implicit alliances based not so much on treaties but through parallel national interests of countries even though some of them may be non-aligned in the context of the classical East-West conflict. Moreover, even if a nation is a member of a military alliance, it follows an independent role largely dictated by its national interests.

2. Role of big powers in disputes between developing nations

The success of arms control through nuclear deterrents in the East-West confrontation has itself created conditions under which the divergent political and economic interests of countries find full scope for expression. Let us, at the outset, recognise that the national interest of a developing country are often in conflict with those of another. An interesting consequence of the triangular polarisation of the world during the fifties was that while the so called "non-aligned" nations tried to maintain a position of neutrality vis-a-vis the East-West conflict, the big powers maintained a neutrality in disputes between the non-aligned nations, which

had successfully resisted the seduction of joining one of the military alliances. The non-aligned status had often the overtones of securing opportunistic advantages as a price for keeping out of a military alliance. The neutrality of the big powers was often consciously promoted through a well meaning intention of preventing the spread of the old war to these countries. Coupled with this was a desire to provide economic and technical assistance to developing nations, partly on humanitarian grounds, partly from enlightened self interest arising out of a conviction that vast disparities in the economic standards of different countries was itself a potential cause for conflict is the future. In any case, the big powers became instrumental in creating the potential through which developing nations could resort to the use of force in settling their mutual disputes. Neutrality vis-a-vis the disputes of developing nations and the parallel support to their war potential create a fertile ground for the outbreak of hostilities between developing nations. The difficulties of the situation are compounded when the big powers possessing a veto within the United Nations machinery for collective security, carry over their neutrality to the extent of negating the very principles on which the framework of collective security must rest, that is, to identify the aggressor who violates the territory of another country and to bring him under control.

3. <u>The role of developing countries and the big powers in supporting collective security:</u>

For developing countries, the only alternative to an arms race is the provision of a system of safeguards and

collective security, which can come into effect speedily and without political overtones whenever the territory of one nation is threatened by another. This is of course one of the most difficult things to achieve in the present state of the United Nations. However, the recent example of big power accord in relation to the intervention by the United Nations to halt the recent fighting between Pakistan and India is one of the most hopeful signs. Side by side with it, there is growing disillusion and scepticism concerning international safeguards and declarations ensuring arms control, when they are not backed by deterrents. The inability of the U.S. to prevent the use of weapons received under U.S. Arms Aid by Pakistan against India illustrates the weaknesses of present day safeguards

There is an understandable sensitivity amongst big powers on being branded as overlords with intention to dominate the world if they are to throw weight behind measures to secure arms control in disputes affecting developing nations. This sensitivity, in my opinion, is misplaced when the measure are undertaken through the U.N. with the backing of the majority of the nations represented in the U.N. The United Nations' constitution gives a privileged position to the big powers within the Security Council and hesitation to act unequivocally for fear of being misrepresented can only lead to a paralysis of the machinery of collective security, as we have seen on many occasions in the past. As a citizen of a developing country, I feel that the solution rests as much on an understanding on our part of the facts of life as it does on the attitude of the big nations towards this problem.

4. Problems of Arms Control

The burden of armaments must play a significant, almost crucial role in determining the economic progress of developing countries, which have to rely largely on their won resources for safeguarding their Security. For instance, the expenditure on defence exceeds the total amount allocated for the development of agriculture during the Fourth Five Year Plan of India. It is quite obvious that an arms race significantly retards the growth of living standards in developing countries and in consequence endangers in the ling run, the stability and security of the big powers as well as of the developing countries.

Till such time as progressive measures towards disarmament are adopted by the big powers and the United Nations' peace keeping role is effective, the developing countries are likely to join in an arms race of their own. Programmes of technical assistance indirectly assist this process, while trade through the supply of conventional weapons, in which even the neutral nations of Europe participate, gives further impetus to this dangerous trend. Moreover, arming other to safeguard one's own security is a most important factor in the proliferation of conventional weapons of destruction. The condition of the world today is such that there is a growing attraction for nations to possess nuclear arms. Measures for arms control in disputes between developing countries therefore becomes of the utmost importance as a step prior to disarmament.

It is clear that arms control must be based on a deterrent. In the case of the developing countries, which cannot accept the

crippling burden of massive armaments by themselves since this could only be at the cost of economic progress, the deterrent has to exercised by the United Nations with the Big Powers acting in the consort with the weaker nations. This does not necessaril mean direct military intervention, but a large number of other steps less severe than an all out military confrontation can be quite effective in producing arms control.

If arms control is to be effective, it is well known that the likely consequences of its failure must be known before-hand to both parties. It is in this respect that the record in the past of the assisting nations has been most defective. As long as aggression by one country against another is sought to be tolerated on political or moral grounds the response of the United Nations to the outbreak of hostilities between two developing nations would not be unequivocally clear. This is fatal to the operation of an arms control through deterrents from outside. Viewing developments at close quarters, there is a growing feeling in India that the armed conflict between Pakistan and India could perhaps have been avoided if the attitude and the response of the big nations was known before-hand to both participants. If a hot line is an important ingredient for maintaining arms control between the U.S.A. and the U.S.S.R. a clear channel of communications is equally necessary between two developing countries and those who assist them.

A most significant positive development which should facilitate the future operation of the machinery for collective security is the declaration by the Political Committee of the United Nations on December 21, 1965 concerning non-intervention

by a State, directly or indirectly, for any reasons whatever, in the internal or external affairs of any other State. Also "no State shall organize, assist, foment, finance, incite or tolerate subversive terrorist or arms activities directed towards that violent overthrow of the regime of another State or interfere in civil strife in another State." The adoption of the resolution means that many existing disputes would be frozen except through the agreement of the parties concerned. It does not affect action under the United Nations Charter.

5. Nuclear proliferation among developing countries

The explosions of atom bombs by China focuses attention on a steady transformation in the overall security balance between nations that is occurring. This is of significance to the super powers just as it is to the developing countries. Apart from all other things, the Chinese bombs have demonstrated the possibility of acquiring independent nuclear capability by a developing country. In the absence of an effective system of arms control for disputes other than these involving big powers, the present situation is most conductive for the proliferation of nuclear weapons. It is argued in developing nations that an independent nuclear capability might in the long run be less expensive than conventional arms for safeguarding a nation's security.

Super powers as well as developing countries find themselves at cross roads at which they have the option of taking the path of ensuing collective security within the U.N. or participate in a new and dangerous arms race. The type of self-restraint which super powers are called upon to exercise

in desisting from deploying A.B.M.installations is also the type of self-restraint which many countries in the world, such as Japan, India, U.A.E. and Israel are called upon to exercise in denying to themselves the acquisition of an independent nuclear capability. This self-restraint must arise out of an act of faith in the political wisdom and maturity on nations of the world acting collectively. However, the faith is precariously balanced and urgently calls for clear measures which will safeguard nations against the use of force. It requires courage to brand a nation as aggressor and to deal effectively with it through the United Nations.

The Committee on Arms Control and Disarmament of the National Citizens' Commission of the United States has recently made pertinent observations for halting the spread of nuclear weapons. It states:-

> "First and foremost among these incentives are the security problems of the non-nuclear powers. Non-nuclear states must be protected from the threat of such force as would persuade them that nuclear wepons were an easy, a necessary, an urgent counter. This requires that nuclear powers commit themselves to refrein from the use, or threat of use, of nuclear weapons against non-nuclear ones. It requires that nuclear powers must pledge themselves to defend the victims of such aggression with all necessary means. But perhaps most important, it means that nuclear and non-nuclear powers alike must commit themselves to refrain from the use of force across national boundaries and must commit themselves, in as

wide a variety of circumstance as possible, to prevent others from doing so. So long as boundaries are or might be changed by force, so long will nuclear weapons appear a potentially useful deterrent to aggression.

We therefore support the formulation and ratify-cation of suitable regional agreements aimed at guaranteedin borders to the satisfaction of those countries most tempted to purchase nuclear weapons for this purpose. In addition, of course, we stress the importance of institutionalizing peacekeeping arrangements.

The Committee recognizes, however, that some of the incentives for nuclear proliferation are political, requireing for their diminution either evidence of major-power willingness to cooperate to keep the peace or, to the extent that nuclear renunciation is a sacrifice, evidence that the major powers are themselves showing a comparable restraint in their effort to halt the “vertical” proliferation of their own arsenals. To this end, the Committee suggests six measures on which immediate agreement should be sought:

(a) A comprehensive ban on nuclear testing, adequately verified. New improvements in National detection systems might make it possible to accept a treaty in which inspection followed a challenge based upon a threat of withdrawal; ultimately any quota of inspections is no more dependable than such an arrangement would be. Alternatively, new improe-ments in seismological instruments might make it posibble to close the small gap in views of the two sides on acceptable numbers of on-site inspections whose existence prevented agreement in 1963.

(b) As an earnest of their intention to limit and reduce strategic weapons, a pledge by the nuclear powers to commit an agreed fraction, such as one-half of

one per cent, of their military expenditures to appropriate UN organs for peace-keeping and economic assistance.

(c) A complete halt in the U.S., U.K. and U.S.S.R. of production of fissionable materials for use in nuclear weapons, as has been recently proposed by the United States; alternatively such more gradual measures as would be acceptable to both sides and essentially symmetrical in their effects.

(d) A transfer for non-weapons uses of agreed quantities of weapon-grade U-235 by the U.S., U.K. and U.S.S.R. to the IAEA for the benefit of developing countries. Safeguards should permit the repossession upon demand of any such material used in an unauthorised manner, e.g., in research which is directed towards the development of nuclear weapons.

(e) Elaboration and intnsification of IAEA inspection and the subordination of all transfers of fissionable material to IAEA controls.

(f) Whether the halt be gradual or complete, an opening of all U.S., U.K. and U.S.S.R. atomic energy plants to IAEA inspection to ensure compliance with the agreement. The U.S. initiative in opening the Rowe, Massachusetts, reactor to IAEA inspection should be broadened, unilaterally if necessary, and it should be matched by the willingness of others engaged in peaceful uses of atomic energy to permit inspection."

We would do well to ak the question whether in addition to measure for the non-proliferation of nuclear weapons, the world is not ready today to restrict the transfer of conventional weapons and armaments technology.

Implementing Change Through Science and Technology

VIKRAM SARABHAI

THIS ESSAY explores six questions pertinent to government policy for science in a developing country. First, what is the most appropriate way to take science to industry? Second, how does one, create centers of scientific research and development in new fields? Third, what administrative practices are appropriate for government in science? Fourth, how is research to be viewed-as overhead or as investment? Fifth, what is meant by planning research? Finally, what can government do to implement change through the application of science and technology? At the outset I will present some summarized case histories of experiences relevant to problems of implementing change. These will help give flavor to some general comments that follow.

In 1948, I had the responsibility of establishing the operations of the Ahmedabad Textile Industry's Research Association (ATIRA), for which industry and government shared costs. We were given a great deal of money, judged by standards then prevalent, but no one had a very clear idea of what should be done. Questions put to managers and technicians within industry did not provide specific answers, but convinced us that ATIRA could be most helpful if it supplied skills and insights and encouraged ways of looking at problems that were complementary to those generally available within industry.

Our core group in ATIRA started off with a mathematical statistician, a social psychologist,[1] a high-polymer chemist, and a solid-state physicist — all

[1] Dr. Kamla Katur Chowdhury, whose paper on "Social and Cultural Factors in Management Development in India," prepared for the International Labour Organization meeting of experts in November, 1965, explores some of these questions from the useful vantage point of the social psychologist. (Management Development Series, #5,1966, pp. 52-64.)

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fresh from advanced research in universities. All, including myself with a background in nuclear physics, were under 30 and none had had previous experience in textile technology. Initially, we felt our task was to observe operations in industry, hoping that in understanding technology we would be able to apply the scientific method of analysis, to ask some basic questions on why things were done as they were, and perhaps to help shrink the time-lag between discovery and implementation of new developments.

We ran into serious problems when we entered an organization at the invitation of its director. We were greeted with attitudes reflecting deep insecurity, often even expressed hostility, on the part of people working permanently at different levels in the company. We succeeded, in some measure, when we were able to become members of a joint investigating group and had largely overcome our identities as outside experts. We found, moreover, that visiting experts who were eager to achieve demonstrable results in short periods, who had no long-term commitments to the project, and no responsibility to live with the results of change, were often most disruptive.

The following conclusions from this experience stand as the most important.

1 In implementing change, we must apply ourselves to people before we can apply ourselves to problems.
2 The biggest obstacle to innovation most often arises from social factors within organizations rather than from the absence of technological know-how or equipment.
3 Organizations that were already leaders in the industry, and presumably had the over-all climate that was conducive to change, were generally also the ones that could benefit most effectively from their association with ATIRA. In other words, the companies that could do most with innovations were the ones least able to receive help from outside ex perts.
4 For relating science to the real problems of society and for the applica tion of results, a cooperative research association using industry as a partner has many advantages over laboratories that are governmental or quasi-governmental in character.

When we look at the development of science through governmental or quasi-governmental organizations, we also find numerous problems. Homi J. Bhabha described some of these in two case studies. In quoting his observations, I should emphasize that today there is increasing realization of measures needed to remedy some of the defects he highlights.

The standard method of planning laboratories and filling posts is often forced on many by the administrative and financial requirements of Government. A

Planning Officer is appointed for planning the work and building of each laboratory. The plan is usually drawn up on the basis of the work of similar laboratories abroad, divided into divisions and sections, and an estimate of the staff required made on this basis. An attempt to fill the posts is then made on the basis of advertisement, and invitation also in the case of the senior most appointments. While this method of setting up a laboratory might give reasonably satisfactory results in a developed country in which science is already an important activity and a large number of scientists already exist in the universities and in other public and private laboratories and research institutes, it has serious disadvantages in a country in which organized science is still in its infancy and the number of available outstanding scientists limited.... A result of following this method has been that a number of good scientists have been drawn away from the universities into the national laboratories, leaving the universities weaker thereby. . . .[2]

Bhabha also discussed the role of scientific administration, pointing out that while India inherited "extremely competent administrative services" from pre-Independence days, those services were geared to industry or to law, for example, rather than to science. This lack, he said, was "a bigger obstacle to the rapid growth of science and technology than the paucity of scientists and technologists," who are less effective if they do not have proper administrative support. Bhabha maintained that as long as the government spent large sums to support research and development, it was in the government's interest to devise efficient administrative and financial procedures for scientific institutions in order to receive a maximum return on its investment.

The application of science to the real tasks of a nation reveals the need for an interactive type of leader, rather than a "boss," to be most effective. He is required to relate himself to the work of others, to give as well as to receive. In Indian society scientists encounter a curious difficulty in accomplishing useful, tangible results. Intellectual endeavor is placed on a very high social scale, but those who are engaged in it are regarded as unfaithful if they should be concerned with day-to-day, practical affairs, including their own standards of living and job security.

Research scientists in national laboratories or academics in universities are looked down upon if they engage in outside consultation or if they choose to augment their income from task-oriented projects of a practical nature. We implicitly promote the ivory tower, and the alienation of persons of insight from "those who do things" is encouraged by such an attitude. This is cause for alarm, because those posing the basic questions are the ones best able to do the applied work. In most situations, identifying the real problem goes a long way toward solving it.

[2] Bhabha, Homi J. "Science and the Problems of Development," *Science,* 1966 VI 151,

To create conditions under which science and scientists can be applied to the real problems of society, we must encourage scientists to interest themselves in problems outside their fields of specialization. To be sure, the opinion of a scientist should not be given special weight in fields other than his own. However, a person who has imbibed the ways of science injects a new viewpoint into a situation; hopefully, he may also offer a degree of enlightenment on the approach to problems, and thus provides a valuable kind of leadership.

This does not mean getting scientists onto diverse committees. There is plenty of that. However, we must make it possible for them to work in their own fields of specialization in addition to undertaking, or collaborating in, other related areas. Innumerable situations in which this is possible lie on the doorstep of every individual. They could be related to improving curricula and methods of education, to setting up local industry or promoting the productivity of farms, to local and regional planning, to implementing programs for population control or community development.

In Ahmedabad, for instance, a Group for the Improvement of Science Education was begun four years ago. This group consists of teachers from schools, colleges, and research institutions, and some gifted students, brought together by a strong personal motivation to improve understanding of science and the standards of education. They are ready to question, to innovate, and to share experiences. At each level, wherever they work, they provide the type of leadership we are considering here.

We know through experience that conditions of work in specialized scientific fields in India rarely match the facilities available in several other countries. It is often frustrating to strive against heavy odds. Some scientists leave the country; however, those who can apply their insights to the problems of the community and the nation discover an exciting area of activity where effort is rewarding even though the results may come slowly.

What should we do to provide the opportunity for such leadership? Attitudes that segregate scientists and intellectuals from the rest of the world will not change quickly. We are not likely, in the near future, to provide scientists and teachers with job opportunities arid service conditions that are on a par with those enjoyed by administrators. Nevertheless, we can provide encouragement to those who will accept responsibilities for real tasks, big and small, while they continue to do their own work. We can, moreover, work to secure acceptance of the notion that such task-oriented activity, seriously undertaken and with a well-defined objective to be realized in a given period, should receive financial reward that will ameliorate the total situation in at least one important aspect.3

[3] The preceding seven paragraphs have been adapted from Vikram Sarabhai, "Leadership in Science," *Yojana,* February 6, 1966, pp. 11-12.

Finally, we come to the question of government policy on the application of science and technology for development. This involves us in the area of government planning for science — assigning the resources required and relating these to other national priorities.

India has recently been spending about 0.2 to 0.3 per cent of its gross national product on research, compared to a figure of 0.8 to 1.5 per cent spent in other countries that either have reached a take-off point or have already attained a developed economy. The provision that has been proposed for the draft Fourth Five-Year Plan will not appreciably increase the low percentage allocation for research. This can be interpreted to mean that science is still being perceived as overhead rather than as investment. Obviously, the responsibility for this state of affairs lies as much with scientists as with elite groups who determine the role of science in our society.

What can the government do in these circumstances? Here are several possible steps.

1 Keep up the open-ended support of those individuals and organizations that have demonstrated the quality of excellence in their work.
2 Where there are major deficiencies in scientific effort in particular areas-as, for instance, in the biological and the earth sciences or in agriculture and engineering —special support must be given to scientific groups for task-oriented development projects that are subjected to prior political decision-making.
3 Prepare a list of developmental and applied research tasks to provide a basis for initiative. First, we must identify specific tasks on the basis of preinvestment studies made quantitatively, competently, and without ideological bias. The studies should evaluate the social, technological, and economic implications of the choices that may be possible in accomplishing the tasks. This exercise requires sophistication as well as a keen awareness of contemporary and advanced science and tech nology, and is one which calls for the collective attention of the best interdisciplinary groups the nation can assemble. An international team may sometimes be even more effective than one which comes from a single social and cultural background. The studies should concern themselves with such things as organization, personnel, and adminis trative practices for implementing change on the basis of political de cisions to be made. Second, we need test-marketing operations to study the response of the groups affected by change brought about by the application of science.
4 Undertake measures to create awareness among the elite of the nation about the scientific method and the implications of science for society. Included here are politicians in government, in parliament, and in

party organizations; civil servants and administrators; industrialists, merchants, and financiers; technicians and managers; professional soldiers; and the scientists themselves. We must understand how this is to be accomplished. Essentially, it calls for leadership by scientists, engineers, and technicians of the country if they are to emerge from their encapsulated existence. Only then is there hope of moving ahead in applied science and of making a major investment in it.

Such endeavors would give a new meaning to planning for science and development, and should be the immediate objectives of the science policy of the government.

National Programme of Talks Series:-
'Exploration in Space' Talk :- 'Sources of Man's Knowledge'
by Dr. Vikram Sarabhai

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I was reading the other day an account of some famous Spanish Captains, who, many Centuries ago, undertook daring voyages of exploration in unchartered oceans far from home. The explorers had to persuade their King to provide good ships with men and stores. They presented prospects based partly on the fragmentary observations of earlier explorers, but largely on imaginative dreams. Craving for knowledge, a romantic love for nature and adventure, lust for wealth and power, courage of a rare type - these were the ingredients which pushed forward man's exploration of the earth. Today the scene differs only in detail, in dress, and certainly in the number of copies in which project proposals have to be submitted to sponsors.

2. What urges man to explore space, the vast and seemingly boundless region which extends beyond 20 to 30 kilometers from the surface of the earth? In answering this question, it is useful to identify four regions of space. We have firstly the earth bound space which constitutes our immediate environment encapsulating a small domain in the solar system. It comprises the region in which the influence of the earth's magnetic field extends, and since the upper atmosphere largely consists of charged atoms, molecules and electrons which are affected by the magnetic field, the material environment is also quite

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distinctive in this region. Beyond it we have the second region which is interplanetary space bound to the sun. This is largely dominated by an extremely rarified and continually expanding gas from the outer corona of our sun. Such rarified gas, in this case composed of charged particles, mostly electrons and protons, is called 'plasma'. Earth bound space is contained in plasma flowing from the sun, a 'solar wind' as it is called. This provides a new medium to carry solar influences to the earth and to the other planets. Largely on account of this wind, the tails of comets always point away from the sun. For the same reason, the earth's magnetic field is blown out in the form of a tail.

3. Beyond the solar system at a distance from the sun about 40 to 50 times that separating the sun and the earth, we have interstellar space in our galaxy, which is our third region. Here too we have a very rarified medium of neutral and charged constituents of matter in space separating the stars. Astronomers talk of yet another space beyond our galaxy where there are countless other galaxies and strange bodies. Extra-galactic space is the fourth region.

4. Many people suppose that there is the absence of the imaginative and intuitive element in the pursuit of science in contrast to philosophical, literary or artistic endeavour. This surely is a fallacy. What distinguishes the scientist is his compelling urge to test his concepts in terms of observations. He is ready to let his castle crumble to dust on the results

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of experiments. As long as man was tied to the solid earth, all he could observe of the outside environment was through information gathered from radiations which could penetrate the atmosphere and the magnetic field of the earth. He had access to only a few windows in the vast spectrum of electro-magnetic radiations. Optical and radio astronomy provided the base for our early concepts so the solar system and of the Universe. He had moreover information derived from low energy charged particles which could approach the earth near the Poles and formed beautiful auroral displays. He could also study the more energetic cosmic rays created in the galaxy through as yet imperfectly understood mechanisms, and some-times those coming from the sun. From all these a complex edifice was built of theories of cosmology, of galactic and stellar structure, of matter and fields in interstellar and interplanetary space and much closer to us, of the configuration of the earth's magnetic field and of phenomenon in the earth's atmosphere. Research. with rockets which make excursions into space, or with satellites which remain in orbit around bodies such as the earth, the moon or the sun, free us from the severe constraints imposed on our ability to make direct observations relevant to these theories. New results of the last few years have already confirmed several theories and concepts derived earlier. They have also demolished many others.

5. Some of the fundamental problems which concern scientists today are no different from those that have excited man's curiosit

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from earliest times. We would like to understand the creation of the Universe, the solar system, the stars and the planets, the origin of life itself and the seemingly mysterious influences through which the sun affects the course of human existence on earth. Space research is related to all these. 6. As technology progresses providing new capabilities for space exploration, it is possible to reach out from observations in earth bound space to the moon and the planets in interplanetary space. The studies of the solar wind in which the earth swims, and of the particles and fields carried with it probably acting as trigger for many occurrences on the earth, are some of the immediate objectives of space research. Another, which concerns the study of planets is of interest to geophysicists as well as to biologists. The earth has a molten core with a magnetic field and a wide range of chemical elements and compounds in its interior and in the atmosphere. These environmental factors along with those related to the mass of the planet and its distance from the sun which controls its temperature are presumably related to the existence of life on earth. But one of the most truly remarkable aspects of life as we know it is that its basic building block, whether in a blade of grass or in a microbe or in man or in giraffe in all cases is the wonderful substance called 'DNA'. This type of life can survive only within a certain range of environmental conditions. We would like to know whether other planets have environmental conditions, which would permit life based on the DNA molecule. Or is it possible to have other forms of life,

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which are based not on carbon, hydrogen, oxygen and nitrogen, but other combinations of elements including iron, as is conceivable in Mars. At this stage we run into speculations, but scientists will not rest till they confirm these through observations. It may well be that there is no other planet in our solar system which can sustain life, but then there are hundreds of millions of stars like our sun which can have their own planetary systems. At the present time many implicitly carry a conviction that life is unique on earth. If and when this proves to be wrong, I would like to suggest that a very fundamental transformation will occur in the way man looks at life and nature.

7. There is an active debate in the world today on the value of space exploration in the context of the many immediate problems of human existence. Why does man wish to go to the moon when he has sophisticated instruments including television cameras, which can be sent in spacecraft under command and can communicate information from millions of miles. It is because nothing that has been developed with the most sophisticated technology so far approaches anywhere near the capability of man who possesses the facility of receiving information simultaneously from a number of channels and to synthesise it to create an image of the environment as a whole. Let us note here that our present day computers and systems for analysis operate only serially i.e., taking one bit of information after another. It is unlikely that man will restrain his

urge to see, to feel and to listen, himself if he can possibly accomplish all these. I do not expect that the debate on the merit or otherwise of putting man into space would ever be settled. If we are to rely on historical experience, man will surely push ahead with adventures of this type backed by motives which will inevitably be mixed.

8. In India the immediate goals of our space research are modest. We do not expect to send a man to the moon or put elephants, white, pink or black, into orbit round the earth. Our objective is to understand primarily the region of the atmosphere from forty to about two hundred kilometers above the surface where ballons will not reach and satellites cannot operate for any 1ength of time because of the drag of the atmosphere. This region of the atmosphere which is studied with sounding rockets is crucial to understanding the processes by which solar influences ultimately penetrate to the lower atmosphere where weather changes occur. Aeronomy is a word which was coined not so long ago to describe the sciences including mateorology related to the earth bound space. Study of aeronomy is of great practical application, particularly to a country, such as India, where much of the gross national product is dependant on rainfed agriculture.

9. Special consideration is now being given to the peaceful uses of outer space of particular significance to developing countries. A most exciting prospect within our reach in the next few years is the establishment of what is known as a

synchronous satellite over the Indian Ocean. It would keep constantly under observation the vast area of the Indian Ocean which has as yet very few observing points from which we can derive information of great importance to meteorology and long range weather forecasting. An equally exciting development is a synchronous direct broadcast television satellite which would make available a most powerful means of mass communication to reach about two thousand million people in an economically depressed region of the world. Physical, and financial inputs are of course necessary for their economic and social uplift, but surely an essential ingredient of our success is the ability to communicate with the widely dispersed population in the region for improving agricultural productivity and permitting programmes of population control. Space research also conferm an invaluable, though intangible, advantage through the spread of advanced technologies which are related to economic development and security. These technologies should materially assist developing countries, such as India to leap frog from their present status.

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Reprinted from Impact of Space Exploration on Society' Volume 8, Science and Technology Series, 1966, a publication of the American Astronautical Society. Publications Office P.O. Box 746, Tarzana, California 91356

THE VALUE OF SPACE ACTIVITY FOR DEVELOPING COUNTRIES

Vikram Sarabhai*

I deem it a great privilege to be invited to address this meeting on the Impact of Space Exploration on Society. The navigation of the Mariner IV space-craft to successfully accomplish a fly by mission to Mars and the telemetry of television pictures from a distance of 13.5 million miles are mile-stones in technological and scientific progress. While applauding the magnificent accomplishment that these represent, we should also appreciate the understanding displayed by the organisers of the mission of their responsibility to the scientific community and to the society at large to preserve the possibility of detecting life on Mars uncontaminated by biological organisms transferred from the earth.

At first sight it may appear odd that a developing nation such as India, where the annual per capita income is about 80 dollars at current prices, where the average expectancy of life is 45 years and the population grows by about 13 millions each year, should think of things other than the immediate problems of population control and of providing food, clothing, housing, education and the social services. What is the value of space research to such a country ? People seriously ask this question both at home and in foreign lauds. And yet we have a modest space programme with which I have been connected from its inception some four years ago. I, therefore, feel it appropriate to share my thinking with you.

Chairman, Indian National Committee for Space Research

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* Chairman, Indian National Committee for Space Research

Some of the comments which I make are perhaps applicable to all developing countries. Others are of special significance to India. I will deal here first with the close relationship between understanding science and the ability of a nation to develop through the application of science and technology. Secondly, I will deal with the role of international cooperation in an advanced field, such as space research, in the transfer of know-how and technology and the creation of an overall climate, vitally necessary for a developing nation. Thirdly, I will discuss the significance of collaboration between advanced nations in jointly undertaking assistance to a developing nation and of the U. N. sponsorship of the International Rocket Launching Facility in India. And finally, what is perhaps most important in an immediate sense, I will relate the value of space research in India for improving understanding of equatorial aeronomy and some factors governing everyday life in the Indian Ocean region.

Clearly the development of a nation is intimately linked with the understanding and application of science and technology by its people. It has sometimes been argued that the application of technology by itself can contribute to growth. This is certainly true as an abstract proposition, but fails in practice. Witness the state of development and social structure of countries of the Middle East, where for decades resources of oil have been exploited with the most sophisticated technology. History has demonstrated that the real social and economic fruits of technology go to those who apply them through understanding. Therefore a significant number of citizens of every developing country must understand the ways of modern science and of the technology that flows from it.

An ability to question basic assumptions in any situation is fostered by probing the frontiers of science, whatever field one may be engaged in, whether it is Biology, Genetics, Atomic Science or Space Research. It is this ability rather than an empirical hit and miss approach which proves most effective in tackling the day to day problems of the world. It follows from this that countries have to provide facilities for its nationals to do front rank research within the resources which are available. It is equally necessary, having produced the men who can do research, to organise task oriented projects for the nation's practical problems. In India, space activities may be allocated during the next few years about 4 per cent of the total available funds for non-military research and development by Government.

Pursuit of cosmic rays and space research does not require an apology in a developing nation provided the activities are within a total scheme of priorities in the allocation of national resources. Many of us who are engaged in pure science are also involved in the organisation and conduct of education, of planning and of industrial development in fields such as electronics and chemicals. The role of space activities in stimulating the growth of technology and industry in advanced fields such as electronics, communications, cybernetics and in materials engineering is well recognised in the advanced nations. This applies equally to developing nations such as India.

When a developing nation gets actively interested in a field such as space research, it inevitably establishes collaborative relationships with organisations as well as scientists and technologists in foreign lands. Through these relationships it starts looking outwards from its encapsulated existence born out of an emergent nationalism. It learns to deal with peers, to establish a mutuality even when the flow of know-how and technology is largely in one direction to start with. International

International cooperation in jointly assisting a developing nation, has a special significance to the advanced countries. In a world in which the East-West conflict has dominated the international scene for almost a decade and a half, there are understandable political overtones in the area of technical assistance. On the other hand, many people believe that 10 to 20 years from now, the important problem facing the world will no longer be the East-West issue in its classical form, but one arising from the disparity of the standards of living of vast areas of the earth's population. Indeed the security of the world will then depend on the effectiveness of common endeavour to ameliorate the situation. Programmes such as IGY, IGC and the International Indian Ocean Expedition constitute international cooperation in fields relatively remote from current practical problems. The International Rocket Launching Facility at Thumba in South India is a unique experiment in international cooperation in the field of space research. At Thumba, the space organisations of France, U.S.A. and the U.S.S.R. and of the host country, which is India, have actively participated. The resolution of the UN Committee on the Peaceful Uses of Outer Space brings out the nature of the project. I quote from the official document:-

"The Committee:

(i) Believes that the creation and use of sounding rocket launching facilities (especially in the equatorial region and the southern hemisphere) under United Nations sponsorship would contribute to the achievement of the objectives of General Assembly resolution 1721 (XVI) by greatly furthering international collaboration in space research and the advancement of human knowledge, and by providing opportunity for valuable practical training for interested users;

(ii) Notes that such facilities would open possibilities for nations which wish to enter the field of space research and would provide opportunities for practical instruction and training in this field, and would also make possible space research by Member States which are unable, because of economic or technological factors, or the unsuitability of their territories, to support sounding rocket programmes except through co-operative efforts, and would also allow States already possessing facilities to conduct research for peaceful scientific purposes in other regions".

In 1962, COSPAR drew attention to major gaps in the world coverage of sounding rocket launching sites. It pointed out: "The equatorial region has special scientific interest for meteorology and aeronomy. In particular, the magnetic equator is highly significant in the investigation of the earth's magnetic field and the ionosphere". It therefore urged that a sounding rocket launching facility on the magnetic equator be established as soon as possible, as a first step in creating and using international sounding rocket facilities under United Nations sponsorship.

India has a long tradition, going back to several decades, of research in geophysics, solar physics and earth-sun relationships. Scientists have been working in Universities, in Research Institutions and in Government Departments, in meteorology, geomagnetism, ionospheric physics and other areas of aeronomy, on cosmic radiation, solar optical and radio astronomy, the electromagnetic conditions of interplanetary space and theoretical astrophysics. The magnetic equator passes through the southern tip of the Indian peninsula and a range of geomagnetic latitudes from -1° to 25° N is thus available. The strength of the field in India is about the highest that is reached anywhere along the equator and in consequence the distance between the F-2 layer and the lower limit of

the radiation belts is about 800 km. over India as compared to 200 km. in Peru. The presence of high mountains has permitted the establishment of high altitude laboratories near the equator as well as in the Himalayas.

The scientific programme in aeronomy, which is backed up by extensive ground-based observations routinely conducted in India, is of particular interest in understanding the problems dealing with the interaction of neutral and charged particles in the presence of the earth's magnetic field. The studies which are currently undertaken involve, along with sounding rocket experiments, measurements with ground-based equipment of related parameters, analysis of real time telemetry data from satellites and radio propagation studies using satellite beacons. Rocket experiments provide photographs of artificial vapour clouds which give information on wind velocities, shears and regions of turbulence in the vertical profile of the neutral atmosphere from an altitude of 80 km. through the E region up to 180 km. The chemical composition of the ionosphere and the vertical profile of electron density are also studied. Special emphasis is on understanding the nature of the D layer and of the sporadic E. Using magnetometers, the structure, the extent and the movements of the current systems involved in the equatorial electrojet are investigated.

Agriculture is the most important activity on the sub-continent of India. A large majority of the population of 480 millions earn their livelihood from this occupation which is largely dependent on rain that occurs during the monsoons. It is hardly necessary in this audience to stress therefore the importance to India's economy of a better understanding of the processes by which the monsoon rains occur, processes which commence over the vast Indian Ocean, where there are relatively few observing stations undertaking even the normal observations at

surface or with balloons. What applies to the economy of India applies to the economy of most of the countries in the Indian Ocean region. Space meteorology which permits the acquisition of valuable data from satellites as well as with the use of sounding rockets has therefore a special significance for us.

Another area of practical importance is the field of satellite communications. Geographically situated as it is at 75 to 90 E meridian, with a volume of international telecommunications second only to Japan in Asia, a satellite communications earth station is of great importance not only for national needs, but for international hook-ups. Assisted by the U. N. Special Fund, an Experimental Satellite Communications Earth Station is now being set up. Independent of this, it is proposed to have a commercial station in the future. The experimental station would provide unique facilities for training scientists and technologists, particularly from the developing nations, in the new field of space communications.

These then are the reasons why India has embarked on a space programme with particular reference to a region which can be covered neither by satellites nor by balloons. With continued cooperation from the advanced nations, we hope through this activity not only to stimulate the progress of our nation, but also to contribute to science.

Talk by Dr.Vikram Sarabhai, Chairman, Atomic Energy Commission, at Ahmedabad on 8th January 1967, on the inauguration of a series of lectures on MANAGEMENT PLANS arranged jointly by the Ahmedabad Management Association and the Ahmedabad Economic Association.

Dr.Vikram Sarabhai, Chairman, Atomic Energy Commission, today stressed the need for social and political inputs in addition to physical and financial, for achieving a high rate of growth. It was necessary to understand the implications of all four factors and sacrifices that the individual and the States would be required to make before formulating a Plan for the country.

Dr.Sarabhai was inaugurating a series of lectures on the Management of Plans organised by the Ahmedabad Management Association and Ahmedabad Economic Association here today.

Dr.Sarabhai deplored the tendency to blame plans/and planning for all the difficulties in the country and said that it was not helpful to make planning a scapegoat of all the problems that were not solved. The entire issue, he said, required to be viewed from a wider perspective.

The National Planning Committee of the pre-Independence days which had revolutionary thinkers, Dr.Sarabhai said, was transformed into an instrument of Government with the not result that it was today a sanctioning authority without the responsibility of delivering anything except giving a plan book.

Planning is unrealistic when Defence, fiscal policies and foreign affairs are excluded from the purview of the groups which are involved in the planning process. All these three areas are intimately related to national development. He felt that this was a serious omission in our present set up.

Dr.Sarabhai made his own suggestions as to how planning could be approached. He advocated a comprehensive study of the factors inherent in our system and advance planning to meet various contingencies that might arise.

He pointed out the need for an appreciation of errors and natural variations in estimates and gave an example of how one can be misled if one did not realise this fully. India, predominantly is an agricultural country dependent on the vagaries of the mojaio'Qfi and statistics revealed that every five years there was perhaps one drought year and one yielding abundant agricultural production. Our food policy should take account of this. There should be no need to go off balance, and change all long-term measures to meet what is after all a natural sequence of events.

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He said that in planning slogans should be avoided. 1 Plan should not be called an agricultural or an industrial plan. Most of the problems which planning sought to tackle had an inherent time constant much longer than five years, he pointed out. It was hardly appropriate under these circumstances to suggest that emphasis should shift every five years because that was the period which we had rather arbitrarily chosen for administrative purposes. There was today a growing need for framing what is called a rolling plan which takes account of projections 5 years in advance but revises them every year.

Planning, Dr.Sarabhai said, currently amounts to putting together requests/from a number of groups based on wishful thinking. Instead of cutting and adjusting demands, there is need to prepare a series of choices on which political decision making can be done. It was necessary to state what one wanted, as well as what one should do without. There was obviously no reality in "all this and Heaven too" approach.

A Plan should be theoretically sound before it was implemented. Wishful thinking, 'guestimates' and hunches should yield place to detailed working and a scientific study of basic data of inputs and outputs was an absolute prerequisite, he said.

Dr.Sarabhai referred to the delay in the implementation of the Narmada Project and fixing prices of natural gas in Gujarat and said that good intentions should be translated into an operational plan. Political and social factors have to be faced squarely and should not hold up the economic projects endlessly.

Dr.Sarabhai felt that building up of the infrastructure could be left to the Public Sector while in other spheres, competition between Public and Private Sectors could lead to fruitful results. This was fully consistent with our goals.

He pointed out that difference in nature of ownership should not prejudice the basic proposition that the Public Sector could be at least as efficient as Private Sector. In the Atomic Energy Commission, he would try to demonstrate this thesis.

Developing countries would not catch up with international markets unless the concept of cost-structure was understood properly. There was a need for a technological revolution for minimising the cost of essentials like power which was generated in the U.S.A. in modern plants at 2 paise

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kW/Hr. whereas in India it cost 4½ to 5 paise. All economic goods and the entire complex would naturally be dear on account of higher cost and the take-off stage could never be reached, resulting in an over widening gap between the developing and the developed countries.

Speech delivered by Dr.Vikram A.Sarabhai, Chairman, Atomic Energy Commission, on the occasion of the Renaming Ceremony of the Trombay Establishment as the Bhabha Atomic Research Centre by Prime Minister on January 12, 1967.

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Today we are assembled to honour Homi Bhabha, the scientist, the founder of our Atomic Energy Programme, a pioneer in promoting international cooperation in the peaceful uses of the atom, one of the principal architects of modern India in the field of science, the creative administrator who found new solutions to old problems, a dynamic leader, a tireless worker, who enjoyed whatever he was doing and one who combined in a rare manner the aesthetic and intellectual values of life.

"On behalf of the Atomic Energy Commission, I wish to welcome you all here today. We particularly appreciate the warm friendship for Bhabha of the many scientists who have travelled long distances to be with us on this occasion; Dr.Glenn Seaborg, Chairman, and Commissioner Tape of the United States Atomic Energy Commission; Professor Perrin, High Commissioner, and Dr.Goldschmidt, Commissioner, represent ing Commissariat a Energie Atomique of France; Mr.Lorne Gray President of the Atomic Energy of Canada Limited; Dr.Adams, Member for Research and Development of the U.K.Atomic Energy Authority and Dr.Pickavance, Director of the Rutherford Laboratory in England; Commissioner Timbs of the Australian Atomic

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Energy Commission; Professor Duran, Vice-President of the Spanish Atomic Energy Commission; Dr.Kakkar, Chairman of the Afghan Atomic Energy Commission; and Dr.Goswami, representing the Director-General of the International Atomic Energy Agency. Short notice of this ceremony has prevented Dr.Petrosyants, Chairman of the State Committee for the Use of Atomic Energy of the USSR, and many others from attending. Two whom we particularly miss, and who, would have liked to be here, are Sir John Cockroft from England and Professor Emelyanov from the Soviet Union. We are grateful to the representatives of many other nations and to you all for generously responding to our invitation.

On the 20th of January 1957, ten years ago, Shri Jawaharlal Nehru formally, inaugurated the Atomic Energy Establishment and Apsara, the first reactor, on this site. It is now our proud privilege to have you, Indiraji, as Prime Minister rename the Atomic Energy Establishment after Bhabha, Your first visit to us this afternoon as Minister in Charge of Atomic Energy is a source of great encouragement to the many thousand scientists, engineers and others who work here. I greatly appreciate that we have the Govern of Maharashtra, presiding on this occasion, and the Chief Minister of the State, with us.

Almost exactly a year ago, Bhabha stood here to mourn the death of Shri Lal Bahadur Shastri. Soon thereafter, on the 24th of January 1966, he met a tragic end. Looking back

on Ms career, one can observe five phases. The first in the thirties at Cambridge when as a young engineer turned theoretical physicist, he was interpreting new phenomena observed in cosmic rays, particularly cascade showers. He was in the main stream of physics in Europe, at a time when it was at its zenith, influenced by Dirac, Pauli and Bohr.

The outbreak of the Second World War brought Bhabha back to India and marks the commencement of the second phase, in the early forties, at the Indian Institute of Science, Bangalore. Isolated from his colleagues in Europe, he took increasing interest in more abstract aspects of theoretical physics, in spinor algebra, the classical theory of point particles, stochastic processes and Multiple Production of Mesons. One observes the beginnings of scientific collaboration with Indian research workers and students. Through the moratorium in Bangalore, grew in Bhabha a realisation of the needs of India and a clear perspective of his own role in the shape of things to come.

The third phase from 1944 to 1954 was devoted to training scientists and to establish groups under the leadership of competent scientists who could, with appropriate facilities and autonomy of work, develop a school of basic Physics and Mathematics, second to none. While Bhabha continued his scientific work he dreamed of the benefits of atomic energy before the first atom bomb was dropped on Hiroshima and secured

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the support of Jehangir Tata to create the Tata Institute of Fundamental Research at Bombay. The Institute was to play a significant role in laying the foundation of nuclear sciences and atomic energy. In Prime Minister Jawaharlal Nehru, Bhabha found a. patron and a friend who believed in the essential role of science in transforming not only the economy of the country, but also in transforming men. Bhatnagar and Krishnan in the newly founded Atomic Energy Commission in 1948 provided support for the creation of an organisation with full authority and free from all non-essential restrictions or needlessly inelastic rules.

The fourth phase from 1954 to 1962 marks the growth of the Atomic Energy Establishment at Trombay and the increasing preoccupation of Bhabha with problems of technology and of administering change. A significant group of physicists and electronic engineers, nurtured in the Tata Institute of Fundamental Research, were transferred to the new establishment carrying with them an expertise and a culture not commonly seen in Government departments. Simultaneously, the prospecting of Atomic Minerals was pursued energetically through the Atomic Minerals Division.

In the newly created Department of Atomic Energy Bhabha introduced concepts which were alien to established Government procedures. In relation to scientists and engineers, he believed that the criterion should not be to have the smallest

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number of persons necessary for a job, but the largest number who could be gainfully employed. Moreover, when a scientist matured, he should be promoted without having to leave his job. Promotion did not imply handing over charge of one task and going over to another. Positions were created whenever competent people were available for identified tasks. As with personnel functions, Bhabha established for procurement as well as for civil construction new procedures suited to the tasks of a scientific organisation. These traditions and a full-fledged training school within the orbit of the Commission constitute a most valuable legacy left to us by Homi Bhabha.

The first Atoms for Peace Conference over which Bhabha presided in 1955 was a milestone in international cooperation and triggered the release of much information which till then was classified. Bhabha set a new pattern in relationships which recognised the international character of modern science and technology and at the same time emphasised self-reliance. At the Scientific Advisory Committee of the United Nations and at the International Atomic Energy Agency, he pressed hard for a system which would ensure the peaceful development of atomic energy and at the same time provide to all countries the opportunity to share in its benefits without discrimination. His stand was often misunderstood abroad by those who had not recognised that he was the principal advisor to Jawaharlal Nehru who decided on the basis of a national that India would develop her programme only for peaceful purposes.

The last phase which commenced around 1962, involved a logical continuation of the earlier developments at a pilot plant scale in mining and processing of uranium ore, fabrication of fuel elements, manufacture of electronic instruments, of nuclear engineering using reactors, of a plutonium extraction plant, and of other facilities set up at Trombay. Bhabha started taking increasing interest in the industrial and large scale applications of atomic energy, and realising that Trombay was a nursery where new developments must continually take place, he identified fresh sites in the country where know-how and processes could be commercially exploited. Bhabha became deeply interested in the wider aspects of national development, in the Government's Science Policy, in problems of security, disarmament and the social implications of science, in the Pugwash movement. He realised that space science and space technology would be important to the nation in the future and, as he had done at the Tata Institute of Fundamental Research for atomic energy fifteen years earlier, he decided to entrust responsibility to a group working under my direction at the Physical Research Laboratory at Ahmedabad. Now a major establishment for space science and space technology is fast coming up at Trivandrum.

It is difficult to visualise Bhabha and work without the unique relationship which he had the good fortune to enjoy with Jawaharlal Nehru, whose understanding provided

the total support which was needed from Government and Parliament.

Our atomic energy Programme has progressed at the pace at which it has through the invaluable collaboration and assistance of many countries. I wish to take this opportunity of thanking our friends abroad for the assistance they have given, particularly the Atomic Energy Authorities of France, Canada, the USA, the USSR and the UK to mention only some of them.

Where did Bhabha leave us? India has a long way to go to improve the economic and social conditions of its people; but in a country beset with a thousand problems, he left islands of self-confidence and something intangible which help us to keep our heads high. The task of applying atomic energy and space research for the benefit of our nation is just begun. We shall design and build nuclear power stations, providing energy at lower cost than what would be possible with conventional means. By the mid-seventies, we should add about 500 MW of nuclear power each year to our national grids. We shall, moreover, produce our own nuclear fuel of natural uranium and Plutonium. Using these, we shall work for the utilisation of thorium of which we have some of the richest deposits in the world. We shall make the other materials needed for our programme such as heavy water, special alloys, particularly of zirconium, and instruments as well as electronic equipment. We will press

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ahead with applications of radiation to industry, biology, agriculture, food preservation and medicine. We shall build rockets and develop superior ones to study aeronomy and the processes by which weather is created. We hope to contribute to an understanding and mastery of advanced technologies, which must form the basis for economic growth and the safeguarding of our security.

Atomic power stations now being built in some of the advanced countries would produce electricity at a cost of about 2 Paise per k.w. This dramatic improvement in the cost structure of generating nuclear power has occurred as much through economy arising from large size of the plant as through the development of technology. We should note that Perhaps 90 per cent of the fresh generating capacity installed 10 to 15 years from now in the industrailly advanced countries would be with nuclear power stations of large size, while in developing countries such as India costs of generation, if the present trends continue with fossil fuel plants, would be at least 2 to 2½ times as much. If such *a* disparity of costs is not remedied for power which is absolutely basic to any large contemporary economy, agricultural or industrial, is there a hope of emerging from the difficulties in which nations such as ours find themselves? How can one establish foreign trade on a sound basis? This is just one example which illustrates why the gap between the

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developing countries and the industrially advanced countries is widening. I am convinced that the lower the level from which one starts and the larger the gap which has to be bridged, the more urgent is the need to use the most powerful techniques and tools placed at our disposal by modern science and technology. Unlike many other developing countries, India is fortunate in being rich in human material with a long traction of education and professional work. With this priceless resource if properly looked after, it has a special advantage over the advanced nations which have already made a big investment on an infra-structure based on older techniques and methods. Low cost atomic power stations forming a basis for industrial complexes producing metals, fertilisers, insecticides and desalinated water where need may exist; medium range weather forecasting using the new inputs from aeronomy, space research and large computers; weather modification; a wide-band space communication system providing through television a most powerful medium of mass communication are some of the dramatic developments which are no longer in the realm of science fiction. Nor are they to be classed in the category of white elephants. It is obvious that when a nation truly succeeds in leapfrogging, a material change would have occured not only in technological and economic terras, but in the social dimension as well.

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The strength of an organization can be judged by how well it can ride calamities. One of the greatest legacies left to us by Bhabha are the men and women, disciplined and trained, who can continue the task that he started. The Bhabha Atomic Research Centre to be named by you, Prime Minister, will be in the good hands of its Director, Shri H.N.Sethna, and of Shri A.S.Rao, Dr.Brahm Prakash, Dr. R.Ramanna and Dr.A.R.Gopal-Ayengar, the Directors of the principal scientific groups. From the ideals and the values which you, Indiraji, stand for, and the leadership that you provide, we derive inspiration and enthusiasm to work, and as you name this Institution after Bhabha, we shall pledge our dedication to the challenging tasks which lie before us.

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PRESERVATION AND INNOVATION * The Tasks of Government in Developing Countries

By Vikram Sarabhai

I suggest that the main obstacles to growth and development are neither technological nor economic, but social factors. This assertion may jar on those who hold the view that given the economic inputs, the rest of the complex facets of the economy and the nation take care of themselves and produce the desired change. I shall therefore share some of my thoughts on this subject.

It was not until I was made responsible for the Atomic Energy programmes of this country and came face to face with problems of development through the application of advanced technologies and basic research, that I became conscious of the problems that are encountered when Government has to perform a role which goes much beyond the maintenance of law and order and the security of the nation. Collaborating with Dr.Kamla Chowdhry in a study** of the growth of the activities of the Atomic Energy Commission of India, an organisation for developmental tasks, and of Bhabha, an outstandingly successful innovator of our times, I was struck by the illumination of my complex issues.

I recognise that governments are involved in providing stability as well as change to society, two seemingly conflict-

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

ing goals. 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. We would have near disaster if we have a judge who is an 'innovator' instead of a 'preserver'. On the other hand, an educational or a scientific administrator would be sterile and ineffective if he is a preserver rather an an innovator. Most tasks encountered in the contemporary world call for organisations wherein creative thinking and innovation are essential ingredients of survival as well as growth. Industrial and agricultural development, and the conduct of foreign affairs call for innovators, rather than traditional administrators.

It is perhaps useful to note that if in a given situation we are content to leave all environmental conditions unchanged, we can at best achieve an evolutionary change through the natural course of survival and growth. On the other hand, forcing the pace of development needs probing the boundary conditions of each situation so as to push in the direction in which change is possible. The instruments of change have therefore to be those who do not take their environment for granted,

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Most of us are familiar with the hierarchical organisation structures involving vertical controls which continue to dominate governments whose principal role until recently was one of preserving a social order. They carry an administrative service, characterised by anonymity coupled with security of tenure, insulating individuals from outside pressures. The system has built in controls which act negatively, attempting to stop a wrong thing from happening.

To realise how distent this culture is from one wherein innovators are involved in developmental tasks, we can examine some of the factors which have been observed in the study of Atomic Energy. Organisations were built round men, and no organisation chart stood in the way of recognising and rewarding talent. Amongst professional groups of scientists and engineers, motivation and control was largely inherent and contained in professional commitments. Control was exercised through discussion and judgement of peers with administration performing largely the role of service. Autonomy of working conditions and self-development were important to the innovators. Horizontal control systems are effective when they involve mobility and interactions The economic analogue of horizontal controls is competition. Horizontal controls are implicit and do not have to be imposed from above. For instance, if there is a situation where supply exceeds demand, the price is controlled by competition rather than by price control. Each competitor, without having to be told so, fully realises the negative implications of his charging a higher price than others. The military application of it is seen in arms control

through the balance of terror. Armed conflict between the U.S. and the U.S.S.R. during the last twenty years has been prevented not by action of the United Nations, but by the implicit threat of reprisals.

While vertical controls are dependent on a system of reporting and feed-back involving more than one level horizontal controls are dependent on direct interaction at the same level. The 'hot line' between Moscow and Washington is necessary to preserve stability through horizontal controls between the two power blocs. The effectiveness of vertical controls are dependent on the time span of delegation. For instance, if the Public Accounts Committee reviews the operation of a Government undertaking two to three years after an event has occurred, its comments cannot have any possible effect in producing control on tactical decisions by the management. With a time span of this order only a strategic decision such as one involving the establishment of a steel plant could be questioned with relevance to controls.

One may ask why competition which is synonymous with horizontal controls has become associated with capitalism? Are horizontal controls contrary to socialism or the State ownership of the means of production? Would it hurt if Hindustan Steel were not just one company? Would not the managements of Bhilai and Durgapur have positive incentives if they were competing with each other and with TISCO and Indian Iron? Can vertical controls of a Board of a monolithic corporation or of the Bureau of Public Enterprises, or of the Parliamentary Committee on Public Enterprises, or the Auditor General provide adequate substitutes for what can be gained through accountability for task performance in a situation of survival and growth in a competitive economy?

Vertical controls usually specify what cannot be done. The Industries Development and Regulation Act is a typical example of such control. Top bodies involved in such control can rarely function in anything but roles of strategic decision making. When they involve themselves in the decision making processes of day to day administration, the system indeed gets fouled up. I would suggest that since vertical controls inhibit innovation and remove the decision making process from the operating level, they are unsuitable as a system for the developmental tasks of government.

We are not suggesting here the abdication of supreme authority at the top most echelon of government. But one is talking of a self-restraint and exercise of power based on understanding of the control systems appropriate to developmental functions. One is moreover asking for a sophistication which recognises that there is a distinction between a formal and a real organisational structure, the social culture of an organisation being influenced mainly by the men who are in it, the determining factors being their assumptions and outlook on life and their attitudes related to their past training and traditions. It is because of this that one despairs of finding solution to our real problems by only organisational changes.

In research laboratories, and in other developmental tasks it seems important that the Chief Executive, besides being involved in policy-making and administration, maintains 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.

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.

The various factors indicated earlier are inter-related 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.

With the problems that we are facing in the country today, it is pertinent to ask how the considerations which we have discussed are relevant to Government. The foremost need would be to identify activities where developmental functions are primarily involved. Organisational reforms involving systems of horizontal and vertical controls would grow naturally when men who are appropriate for these tasks are placed in positions of responsibility. Will we have the conviction and courage to introduce those changes? The answer is surely crucially related to our survival.

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The Convocation is a ritualistic farewell to those who have graduated after two years of exposure to what the Institute stands for. There is a great emphasis here on the decision-making process. What is equally important is an underataning of the backdrop of the physical and social environment in which we operate. For it is through assumptions made from an understanding of the background that innovators derive their nourishment. I am sure you have acquired plenty of this here, but hope that you will continue to test and renew your assumptions on the experiences that you gain. I wish that you would perform successfully the role of innovators.

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VOLUNTEERS FOR DEVELOPMENT *

by

Vikram Sarabhai Chairman,
Atomic Energy Commission.

I am an admirer of the Indian Institute of Technology and the role that they are performing in modern India. They constitute centres of excellence and of disciplined hard work, bridges linking different States and India with the outside world. They provide a model for what requires to be done in the wider field of education, covering also the humanities and the social sciences, if, simultaneously with a broadening of its base of literates, this nation is to secure its leaders. I am, therefore, particularly grateful to Shri G.L. Mehta, Chairman of the Board of Governors, and to Professor Bose, Director of the Institute, for having invited me to visit the Institute and for the honour of addressing the convocation today.

This Institute is fortunate in securing collaboration through UNESCO of a country which is outstanding in its approach to science. I have visited the Soviet Union several times. The role of science and technology and of scientists and engineers in the USSR is truly remarkable. There is no dichotomy between the pursuit of knowledge and its application, no segregation of social from the natural sciences, no hesitation in identifying the gifted and providing to them the best that the nation can offer. Moreover, there has developed in the USSR during the past few years a rare realisation of international ethics appropriate to technological developments applied to warfare. Present day Soviet leadership has set an example of self-restraint in the use of force in international disputes. It is fully backed by a people who are constantly presented the social implications of science and technology and led to an acceptance of the constraints in international relations in a world with an overkill capacity from missiles with nuclear warheads.

I note that recently the UNESCO project of Technical Assistance to the Institute of Technology at Powai has ended. I hope, however, that the international character of this Institution through the collaborative relationship between the scientists and engineers of the two countries would continue with greater mutuality and that the faculty and alumni of this Institute would contribute to the USSR, as they receive from their professional colleagues from abroad. I suggest that the Soviet attitude towards science and an appreciation of the role that it plays in the building up of the nation, is at least as important to us as Soviet technology. I would wish that this Institute gives as much emphasis to science as to technology, for indeed neither can flourish

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* Convocation address to the Indian Institute of Technology, Powai, Bombay, August 1967.

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without the other. Moreover, we need much wider contacts with the outside world of agriculture, industry and government including Defence, if we are to participate in the solution of real problems by sharing expertise and insights.

You might well ask yourself the question: "How am I, graduating from this Institute, to contribute in the wider sphere of national activity?" Developmental tasks continually require decision-making based not on administrative procedures and precedents, nor even on economic models by themselves, but on the appreciation of hard realities related to science and technology in the context of our social environment. Even though today we find in our country relatively few areas and organisations where trained professionals are associated with decision-making on this basis, there is no doubt in my mind that meaningful development at an accelerated pace, which we must undertake, will not occur until this situation is remedied. Apart from specialised expertise, the application at all levels of the scientific method and basic concepts is involved.

I would illustrate this with an example drawn from an area with which I am familiar. Most people would recognise that in the contemporary world Governments are called upon to play an increasingly comprehensive role in diverse activities of the nation. They inevitably set up control systems to achieve national objectives and goals. Those who have studied even the elementary aspects of the science of control systems are aware of three essential ingredients. These are:

First, that in order to control a system, one must have a feed-back loop, which transmits back to the controlling centre information about the system which is being controlled.

Second, the feed-back should be transmitted as quickly as possible and without noise or distortion. In fact the system would be out of control if the feed-back takes longer than the time constant which is inherent in the main system. For instance, if an airliner is flying from Bombay to Cairo and the pilot asks for his position over the radio from one of the ground stations, it is no use his getting the information many hours after he is supposed to reach his destination, nor if the information itself is garbled or inaccurate. If, on the other hand, one is dealing with interception of hostile aircraft using radars and fighters, the time constant for the feed-back must be fractions of seconds and involves sophisticated computers to figure out the response that should be given.

Finally, one does not start giving corrective signals in a control system at intervals of time small compared to the inherent time constant of significant response of the system itself. For instance, if I wish to administer a fertiliser in the most effective manner to maximise the height to which a banyan tree would grow, I would not go on changing my technique of administering the fertiliser very two or three months by looking at the little sapling which has barely come out of the ground. In real terms, for example, if the time constant of

the educational process corresponds to the span of a generation, one does not drastically alter the national policy for education every three to four years, as we are currently attempting to do.

There is nothing profound about what I have said here. However, I suggest that when we have accepted in this country the necessity of the Government taking a great deal of direct interest in promoting development and, hence, in controlling diverse facets of national life, these elementary considerations must be satisfied if we are not to fail flat on our faces. In my experience, it is very rare indeed to find the basic requirements of control systems in fact obtaining in any real situation.

I have come across this problem head-on in connection with responsibilities which I shoulder as Chairman of the Electronics Committee of the Government of India, responsible for advising on the implementation of the recommendations of the Bhabha Committee. You would probably be interested in learning what exactly is the problem. If we are to be self-reliant in the field of Electronics applied to Defence, telecommunications, industry, agriculture, scientific research and entertainment, we have simultaneously to undertake the following. We need not only to build complex electronic equipment involving systems such as a radar, but the subsystem which go into the equipment, the components which are involved in the sub-system and the special grade raw materials which are needed for making the components. Moreover, we need to design and develop each of these systems and components as well as acquire industrial know-how to produce these economically. Most important, at least for Defence, we need to visualise the needs of equipment for the future and start designing now.

According to normal governmental practice one would rely on the Industries Development and Regulation Act, the control of foreign collaborations, the Foreign Exchange Control Regulation and the Import Control Regulations. I suggest that these instruments are incapable of providing the necessary conditions for reaching our goals. Even if we do not question the appropriateness of these instruments available to Government for ensuring the required development, one comes across a rather gross detect in the administrative procedures attached to each one of these control systems. At this Convocation, it is hardly appropriate to go into details, but one is revealing no State secrets when one says that some of the most difficult problems arise from the total inadequacy as well as inaccuracy and delay in the feed-back of data related to real facts of our economy. I would submit that in the complex world of real life, there is no way by which development can be accomplished through instinct or specialised skills without a base provided by the application of the scientific method. Scientists and engineers have to carry this method and approach wherever they go,

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I have touched on the field of Electronics because it is one which I believe is destined to be one of the most important instruments of leap-frogging this country from its present state of poverty to one of sustained economic development. Its potential can be judged from the performance of this industry in the post war period. In the U.S. alone, its volume is comparable to the entire gross national product of this country. It is amongst the fastest growing industries. Being labour intensive rather than capital intensive, the Bhabha Committee estimated that an investment of Rs.4000 to Rs.5000 per worker would be needed here, compared to Rs. 1,50,000 per worker in heavy industries; requiring skills for which we have already a great tradition in our craftsmen, and providing the most effective channel for reaching the isolated communities living in the rural areas, electronics can revolutionise life in this country. According to a recent estimate, using re-broadcasting facilities from a synchronous satellite over the Indian Ocean it should be possible to cover an additional population of about 100 million per year with community television receivers at a cost of about Rs.20 - 25 crores per year. An indigenous micro-wave industry, geared to the needs of such a programme, would also provide the basis for sophisticated electronics needed for Defence. In a joint programme that the Department of Atomic Energy is undertaking in 100 villages around Delhi, in collaboration with the Ministry of Information and Broadcasting and the Ministry of Food and Agriculture, we hope to demonstrate through 80 village teleclubs that television as a medium of mass communication can be an investment rather than an overhead. A demonstration of this type is over due since India should soon make a hard decision between the alternative systems which should be established nationally to provide broad-band communications.

There is a great deal of interest in our country in the development of atomic energy. But our progress in this field is not matched in many others, equally important for the overall development of the nation. The gaps in electronics and in aerospace technology arc very wide. along with these advanced fields, we are currently totally reliant on imported know-how in many very much more well established areas of industrial activity. If we are to bridge this gap, which we can only ignore at great peril to our nation, we shall require imaginative programmes of development which promote, rather than control. Moreover, there is a price to be paid. A study of development the world over in the post World War II era shows that a financial investment of about 1 per cent of the Gross National Product of a country for research and development is the minimum that is necessary to achieve self-reliant and self-sustaining growth. We have never spent more than a third of this figure in this country. When we run into economic difficulties, it is very short sighted indeed if we hesitate to allocate adequate resources to the very activities which are likely to take us out of this depression.

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An analysis of the reasons why inspite of the Scientific Policy Resolution of the Government of India we have not made a better investment in research and development leads us to complex issues. Amongst these, one fact stands out very clearly. This is related to the attitude of scientists and technologists themselves. We have projected and come to accept unreasonably large time constants for undertaking even important national tasks of great urgency. We have got accustomed to public sector projects which take five to seven years to mature and research and developmental projects which take eight to ten years to complete. Both these time factors are, *I* submit, totally incongruous in the contemporary world of accelerating change. We have to learn to set up normal type of factories in one to two years, at least in fields such as Electronics. Recruitment and training of personnel for production can be undertaken simultaneously. We have also to learn to mobilise research groups to be able to undertake development of systems in periods of two to three years. It is only then that we may hope to keep our heads above water and swim with the advanced nations of the world.

In talking of self-reliance in scientific research and technological developments, one is sometimes apt to equate it to nationalism. To this audience I do not have to emphasise the importance of a free flow of information and expertise and the need to start at a point where others have left it. The problem arises when one takes something from others and does not simultaneously start an activity to go beyond it. In the atomic energy field, for instance, we would have been unjustified in undertaking collaboration with Canada for the Rajasthan Atomic Power Project if we had not simultaneously commenced the designing and building of the Madras Atomic Power Project on our own.

The graduates of this Institute and the other Institutes of Technology and learning in this country are flailed upon to provide the sinews of growth, as 'volunteers for development'. I wish and hope that this country would do well by you.

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Development through Pace Setting: Horizontal and Vertical Control Systems.

Bhabha Memorial Lecture delivered by Dr.Vikram A.Sarabhai at the Institution of Telecommunication Engineers(India), New Delhi, December 9, 1967.

It is fitting that the Institution of Telecommunication Engineers should honour Bhabha by instituting a Memorial Lecture. I deem it a privilege to be invited to deliver the first lecture.

1 distinguished civil servant who worked closely with Bhabha for several years remarked to me that, in his opinion, Bhabha was the best administrator he had come across. By this, I am sure, he did not mean that Bhabha was a. quick disposer of files or was easily accessible. He was paying tribute to Bhabha's ability to translate into practice insights and attitudes which were based on sound experience and a conceptual background derived as a practising scientist. With this he was able to create Organisations and execute Projects with elegance and efficiency.

One of the most important tasks that Bhabha completed before his death was the Report of the Electronics Committee which was appointed by the Department of Atomic Energy under his Chairmanship in 1963. This Report which is more commonly known as the Bhabha Committee Report has rightly aroused a great deal of interest and is particularly relevant to telecommunication engineers.

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The role that electronics is destined to play can be judged by comparing the figure of Rs. 13,500 crores which represents the value of electronic goods produced in 1965 in the U.S.with the figure of Rs. 16,630 crores which represents the gross national product of India in the same year. Moreover the urgency and the enormity of the task can be gauged by the ten-fold increase of domestic production from Rs.30-300 crores per year which would be required during the next ten years. Its significance to national security as well as to economic growth cannot be overemphasised. Much publicity has been given to the assessment of the needs during the decade 1965-75 and the targets to be reached in the manufacture of electronic equipment, components and basic raw materials if India has to attain a fair measure of self-reliance. What are not equally well publicised are the concrete recommendations regarding policy for achieving the objectives. Permit me therefore to recapitulate some of these -

The electronics industry has to be considered as a whole and developed in an integrated and inter-locked manner. If the public interest is to be considered, and the interest of the Indian tax-payer, it is essential that all equipment, whether for civilian or military use, should be produced in the most economical manner possible, and this requires that the production of this equipment should be organised according to technologies and economics of production, as is done in the highly industrialised countries.

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If the separation of civil and military production is not required by security considerations even in the technically most advanced countries, it clearly cannot be justified in India. It also follows from technological considerations that production in the public sector cannot be separated from production in the private sector and for optimum development of the industry it is necessary to plan it on an integrated basis taking the public and private sectors together.

Electronics, more than any other, is an industry in which technical persons must be in key positions at all levels, for policy making and for the management of plants down to the individual production operations. In order to develop a self-reliant and largely self-sufficient industry capable of meeting Indian needs and of competing in the world market, the first and most urgent need is to establish in every plant producing electronic equipment, scientific and technical design and development groups with sufficient competence to redesign equipment either being manufactured under licence or whose design is readily available in the literature, in order to adapt it to Indian conditions and to use the components available in India. These groups should also bring prototypes developed in the country to the production stage. In all such work a considerable saving in development time can be effected by dismantling imported equipment and copying its design with such modifications

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as may be necessary to adapt it to Indian requirements. It should be possible within the relatively short period of about a year to redesign equipment or to develop indigenous prototypes from information available in the literature or obtainable from studying foreign models. It is essential that action should be taken simultaneously to design, develop and produce next generation of equipments indigenously.

The very backwardness of the country in electronics and smallness in size of the present electronics industry could be turned into an asset, if early stages in the development of the industry in other countries are bypassed and the industry planned on the basis of the latest ideas and techniques. In no circumstances should India follow step by step the developments of the electronics industry in the more advanced countries, entailing, as this would inevitably, the production of obselete components and equipments and the use of obselete and obselescent techniques and production processes.

The highest priority should be given to establishing the indigenous production of components and establish high grade components required for professional equipments in the country, if the industry is to stand on its own feet and a real substantial saving in foreign exchange is to be effected. It has been found that the economies of scale and the removal of customs duty on imported primary materials for making components or their production in the country, will straight-away affect a 40 per cent

reduction in the price of certain components, and a further increase in the scale of production Will reduce the cost still further.

Expertise is available in the country to design systems, develop equipments and undertake its manufacturing and it is possible to base the next generation of equipment which will come into use between 1970-75, entirely on indigenous designs. It is, therefore, possible to build up a self-sustaining electronics industry in the country within a decade, if development work and progressive switch over of both production and use to indigenously designed and developed equipments is decided upon immediately by Government, as an inflexible policy to be followed with determination.

Where the developmental actions are in an advanced stage and where the executive technical authority is satisfied with the ability and capability of the agency to develop and produce the equipment upto desired specifications, then a calculated risk should be taken and firm orders placed on that agency while the equipment is still under development. This will help to telescope considerably the period involved in the procurement of components and the availability of equipment to the users.

It is essential that India should also participate in long range research, and for this purpose strong support should be given by Government to such long range research, not directed towards any immediate application, both in

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Government supported laboratories as well as in the universities, and, indeed, in any laboratory privately or publicly owned, where there is an outstanding research worker or group. It must be understood that only research workers who have proved their capabilities, and promising young men must be supported for such long range research, which should not be confused with much of the directionless and so-called pure research, which is done in India today. In particular advanced study and research in the solid state should be strongly supported. It must be emphasised that long range research can and must only be built round outstanding individuals in order to vield any worthwhile results.

Inplicit in the approach which has been outlined is a recognition of the culture in which science and technology thrive, a culture in which one relies on horizontal control Systems rather than vertical control systems, a culture in which the role of Government is one of pace setting.

To shall try to explain some important characteristics of the two types of control systems. Let us take the example of the preservation of peace in the world. If we succeeded in creating a World Government and through its power and control it is able to prevent war from breaking out between hostile groups we would have the successful operation of a Vertical Control System. Here the control is exercised downwards from a higher level. However take the case of prevention of armed conflict between the U.S.A. and the U.S.S.R. during the last 20 years. Most people would agree that it is not the existence of the U.N.. or the superior power

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of an organisation at a higher level which has preserved peace. It has been through the operation of mutual deterrents on what is known as the balance of terror. Each side is aware that to resort to arms for the settlement of a dispute would entail its own population being subjected to unacceptable damage. In consequence peace is preserved by horizontal inter-action without anyone from the top ordaining that there should be no war. In every day life we have a number of examples of these successful operation of horizontal controls, e.g. our behaviour with our neighbours or in a community, the manner in which prices are kept down and quality improved through free competition in a situation where there are no shortages. It is in such situations that pace setting by Government can be a most powerful instrument for development. Indeed it can be much more effective than through vertical controls.

In our country where we ideologically promote the public sector, Government has a wonderful opportunity of priming the process of development by setting up pace setting industries and organisations which through.exercising horizontal controls stimulate the overall level of economic development. But this role is impossible if simultaneously one relies on vertical controls which are largely negative in character as in the case of the Industries Development and Regulation Act. We buy the worst of both worlds when in a democratically oriented society one relies heavily on vertical control systems most appropriate to monolithic hierarchical structure.

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Another important moral that is conveyed in the Bhabha Committee Report relates to the process of leap frogging. Let me give an example. In a recent survey made by a Technical Group of the feasibility of Satellite Communications for providing nation-wide television coverage in this country, the following quantitative figures have come up. *As* is well-known one requires a broad-band communication system for television. To cover the best part of the country about 150 transmitting stations covering servicing approximately 8000 square miles per station would be needed. If the stations are hooked up through micro-wave links of the conventional type or co-axial cables we would need an expenditure of about Rs.72 crores. Using synchronising satellite, the system would cost only Rs.23 crores including the cost of the satellite and its launching. In a developing country such as India the difference between 23 and 72 crores might mean undertaking a project in three years or in ten years. Moreover, one would be bypassing technology, it would be becoming obsolete as time goes on.

In analysing Bhabha's role in the growth of atomic energy in India, Dr.Kamala Chowdhry and I made the following observations: There is need to understand that there is a shift from simple to complex technologies, from stability to Innovation, from experience based knowledge and skills to highly conceptual knowledge. The understanding of this change means the recognition of socio-technical systems rather than a mechanistic organisation structure, the recognition that highly trained and professional groups

have different needs and motivations, the realisation that hierarchical structures and systems need to be minimised and that the concept of control is inherent and contained in professional commitments rather than exercised from outside.

I would suggest that if we are to base the growth of this country on the application of science and technology within the democratic framework we shall have to increasingly rely on horizontal controls. Indeed, State enterprise would be primarily directed at pace setting.

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Speech delivered by Dr.Vikram A.Sarabhai, on the occasion of the dedecation ceremony of the International Thumba Equatorial Rocket Launching Station on February 2, 1968.

Prime Minister, Rajpal, Chief Minister, Monsieur de Seines,

Colleagues and friends,

I deem it a great privilege to welcome you on behalf of the Indian National Committee for Space Research, to the dedication of the Thumba Equatorial Rocket Launching Station as a U.N. sponsored facility. Scientists and engineers of my generation are deeply conscious of the encouragement which Shri Jawaharlal Nehru gave in the years following independence and the new role which he identified for science in the development of the nation. We have the good fortune of having you, Prime Minister, carry forward the traditions established by your father. We are proud that you will dedicate this range which, in a sense, marks the entry of India into the space age. We greatly appreciate your interest in our work and your accepting our invitation to come here today.

Jawaharlalji's scientific spirit and internationalism find expression in this activity. I believe it is not accidental that, on the soil of India, the great space powers, the USA and the USSR, and France are collaborating with us in a joint project. We feel deeply the absence of Secretary General U Thant, who was to be with us today as chief guest* But to you, Monsieur de Seines, I wish to extend a very particular welcome, for, you represent here the United Nations to which the people of the world look for peace and sanity in this

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world. U.N. sponsorship of this range is not merely a natter of form, but constitutes an umbrella under which international collaboration in the peaceful uses of outer space could be pursued most vigorously and without the handicap of political differences amongst nations. It shall be our constant endeavour to bring these high hopes to fruition, particularly in giving a meaningful form to space research in a developing nation.

Many of our friends in this country and abroad have generously responded to our invitation. I wish to make special mention of Dr.Bryan Rofe of Australia, Prof.Wilson of Canada, Prof. Blamont of France, Dr.Lauter of the German Democratic Republic, Prof. Hayakawa of Japan, Prof.Wilmore of the United Kingdom, Prof. Shidkovsky of the USSR, Mr.Arnold Frutkin of the U.S.A. and Prof. Napolitano, the President of the International Astronautical Federation. We greatly appreciate your presence here today and look forward to collaboration with your space scientists and organisations on an ever widening scale.

I feel keenly the absence today of Homi Bhabha, with whom I visited this spot four years ago. With characteristic vision, he recognised- the great importance of advanced technologies involved, in atomic energy, in the exploration of space and in electronics. In 1961, the subject of exploration of outer space for peaceful purposes was allocated

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to the Department of Atomic Energy. Soon thereafter, the Indian National Committee for Space Research was constituted. Quite early, the Committee decided to establish a sounding rocket range on the geomagnetic equator at Thumba. It consciously laid emphasis on creating facilities which would permit a study of problems in aeronomy in the region upto 200 km. which is below the operational level of satellites. This was particularly appropriate, since the programme could be conducted with small sounding rockets involving a modest budget. Moreover, the scientific results would have a direct bearing on a better understanding of meteorology of great practical significance to the Indian economy.

Amongst the laboratories related to the Department of Atomic Energy and largely supported by the Department, was the Physical Research Laboratory at Ahmedabad which conducted basic research in the fields of aeronomy, cosmic rays, interplanetary space and solar activity. The major responsibility for setting up the new activity, in consequence naturally fell on the scientific personnel of the Physical Research Laboratory, and in October 1963 the administrative charge for the Thumba establishment was formally entrusted to the Physical Research Laboratory under my direction. Through this, Dr. Bhabha was following a precedent which had worked very successfully in the early stages of the Atomic Energy Programme when the Tata

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Institute of Fundamental Research played a major role. Moreover, through the administrative charge being carried by an autonomous laboratory, which was at the same time closely related to the Department, overall coordination by Government along with the flexibility of an academic type of institution was ensured.

The sounding rocket programme was initiated by collaboration agreements with NASA of USA, with CNES of France and with the Hydrometeorological Services of the USSR. At the same time, for an on-going programme with sounding rockets, an agreement was concluded for the local manufacture, under licence, of Centaure rockets. The responsibility for fabricating the rockets has been entrusted to the Bhabha Atomic Research Centre at Trombay. But the activity will be transferred next year to a new establishment here by the side of a rocket propellant plant that has been set up.

In 1966, the Atomic Energy Commission approved the establishment of a Space Science and Technology Centre with the major task of developing expertise in aero-space engineering, sounding rockets of superior performance and a modest satellite launcher. The Centre is also concerned with ground-based experiments supporting space research and scientific payload construction. The Centre is being set up on Veli Hill, by the side of TERLS. A large group of engineers has been assembled at the SSTC to work in different disciplines of

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space technology involving propellant engineering, propulsion, structural engineering, aerodynamics, materials, control and guidance, technical physics, electronics, system engineering and test and evaluation. The first Rohini rockets, RH-75, have been successfully flight tested in November 1967. Two other projects of the Department of Atomic Energy of particular relevance to space research are being developed by the Tata Institute of Fundamental Research. The Institute has carried out, since 1959, more than 100 major flights with plastic balloons from Hyderabad. The balloons fabricated at the TIFR are capable of flying payloads upto 250 kgs. The large balloons can reach ceiling altitudes close to 5gms/cm^2 and float at that altitude for about 8, hours. The other is a large cylindrical radio telescope in the Nilgiris, which will provide facilities to scientists from Universities to undertake advanced research.

With a long established tradition of research in meteorology, ionospheric physics, geo-magnetism, cosmic rays, astrophysics and solar physics, India has a good scientific base and a deep interest in the exploration of outer space.

Magnetic observations commenced in India in 1841 at Simla, Bombay, Madras and Trivandrum. Among the important contributions may be mentioned the discovery of the 27-day periodicity in the daily variation of the geomagnetic field

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by Alan Broun at Trivandrum, the study of lunar and luni-solar variations by Chambers, and of time variations of the magnetic field during magnetic storms by Moos at Bombay. The Survey of India organised field observations for preparing magnetic maps of India in 1902. Observations both in India and elsewhere revealed unexpectedly large daily variation of the magnetic elements near the geomagnetic equator, which has since been attributed to the presence of a narrow current sheet called "Equatorial Electrojet" in the upper atmosphere.

A solar physics observatory was started at Kodaikanal in 1899. Among the notable contributions made by the Kodaikanal Observatory in astrophysics are the discovery of the outflow of gases above sunspots (Evershed effect), the confirmation of the relative shift of spectral lines, and the discovery of infra-red oxygen lines in the solar chromosphere and prominences.

The illustrated brochure, which is distributed here, reflects activities at the Range. Advanced technology developing side by side with the little child close to nature; radars capable of tracking small fast moving objects at great distances and a nose-cone being transported on a bicycle these truly firm the pattern of modern India. There are some who question the relevance of space activities in a developing nation. To us, there is no ambiguity of purpose. We do not have the fantasy of competing with the economically advanced

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nations in the explorations of the moon or the planets or manned space flight. But we are convinced that if we are to play a meaningful role nationally, and in the community of nations, we must be second to none in the application of advanced technologies to the real problems of man and society, which we find in our country. And we should note that the application of sophisticated technologies and methods of analysis to our problems is not to be confused with embarking on grandiose schemes, whose primary impact is for show rather than for progress measured in hard economic and social terms.

Amongst the most important practical applications of space research are those related to meteorology, to communications and to geodesy. Orbiting meteorological satellites transmit cloud pictures covering an area of about a million sq. km. of the earth's surface. These are received by meteorological stations in different parts of the world including the APT receiving station at the Meteorological Centre, Bombay. The information enables meteorologists to extend weather analysis to areas of sparse observations over land and sea. Operationally, they are useful for the issue of cyclone and storm warnings, for aircraft flight briefings and in aiding navigation of ships. Satellites cloud pictures have revealed the existence of two belts of cloud maxima in the equatorial zone of the Indian Ocean

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even in July, separated by & region of minimum cloudiness at the equator. The meteorological sounding rocket programme conducted from Thumb a has provided very interesting information on the pattern of winds near the equator. This observation has important consequences to our understanding of the Indian Southwest Monsoon.

For the last ten years, the Uttar Pradesh State Observatory (UPSO) at Nainital has been participating with the Smithsonian Astro-physical Observatory (SAO) of the United States in a cooperative programme of optical satellite tracking. The data from Nainital and the other eleven cooperating stations have been used to compute the precise gravitational field of the earth, its shape, and the coordinates of the twelve stations with respect to the centroid of the earth with an accuracy of about 15 metres. The data show that the mean sea-level off Trivandrum is ninety metres nearer the centre than the sea-level off Dover in the English Channel.

Plans are afoot for setting up a satellite tracking station in Trivandrum with more modern equipment. It is expected that data collected there would help in the determination of the coordinates of South Indian stations with a precision of about 10 metres. The coordinates of island stations like Minicoy and Port Blair not connected to any land survey grid can be in error by as much as 500 metres.

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When satellite tracking stations are set up on these, their coordinates also can be determined with a precision of about 10 metres.

An Experimental Satellite Communications Earth Station has been established at Ahmedabad with assistance of the United Nations Special Fund. If we use traditional methods such as coaxial cable or micro-wave links to provide broadband high capacity channels, it is estimated that the capital cost would be about three times greater than what would be necessary if satellites are used. The difference in cost between adopting satellite communications or one of the conventional methods is so large that it materially affects the time for establishing the system. , An investment decision based on an appreciation of the new technological developments is therefore overdue and must be made before national investment in older technologies grows significantly. Indeed this is the only way in which I can see the country leapfrogging into a position where it can hope to meet more developed nations oneequal terms.

Television can be a very powerful tool of mass communication. Its potentialities, particularly in popularising modern agricultural methods as a means to increase productivity, in disseminating information about population control and in promoting national integration are staggering. An intensive programme to educate the agricultural community of 80 villages around Delhi in the use of modern agricultural methods through

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the medium of television, has been undertaken. A comparative assessment of the progress made by these villages with the rest of the country will be made at the end of the pilot project to help us to objectively evaluate the effectiveness of satellite television as a means of mass education.

One of the most important benefits of space research lies in the spin-off which follows, I might illustrate this from the experience which we are gaining in the development of rockets. This involves new disciplines and an understanding of materials and methods; of close tolerances and testing under extremes; the development of guidance and control and the use of advanced information techniques. When one succeeds, it is through the working together of a large number of specialists who dedicate themselves to a common task. Indeed, I often feel that the discipline and the culture of the new world which emerges through the pursuit of activities of this type are amongst the most important from the standpoint of a developing nation.

A question that often arises is whether we are today in the midst of a qualitative or merely a quantitative change. I would like to suggest that with the release of the energy of atom, the growth of electronics and man's ability to operate in outer space, 'the world' has been created. This demands a change of our values. There, is

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no hope for those who wish to advance step by step, following outmoded methods.

It has been a stimulating experience for me personally to work with groups of dedicated engineers at TERLS under the direction of Shri Murthy. To this team and to the Rohini Group in the Space Science and Technology Centre, I offer my sincere admiration. We shall strive for bringing to India the peaceful uses of outer space and promote international collaboration.

THE DIVERGING HUMAN FUNCTION *

By Vikram

Sarabhai

Things have changed a great deal during the last five years. Jawaharlal Nehru, Kennedy and Kruschev are gone from the international scene. Nations already armed to the teeth have continued to engage in a spiralling arms race and bombs rain every day from the skies over North and South Vietnam, Violence is rampant the world over. There is disenchantment with aid and with military alliances. Manned exploration of the moon and, in this country, the pursuit of engineering studies do not have the same glamour as before. Political life in Red China, in the United States and in India, is chaotic and social goals perceived with cynicism.

What is happening around us? Has the uncertain world come to stay with us? The affliction is not peculiar to us; rich nations and poor ones, large and small, powerful and weak, those in military alliances, the non-aligned and the neutral, all manifest the same symptoms. The scenario is different, in France, in the United States, in Poland, in Japan and in India. And so are the methods by which societies try to deal with these problems. But a common thread runs through all these. I wish today to share with you some of my thinking, for, I believe that the present is particularly threatening to those like you who embark on a professional career for the first time.

Every one here is undoubtedly familiar with the expression "three raised to the power of eighteen". It is a large number - 38,74,20,489 thirty eight crores, seventy four lakhs, twenty thousand, four hundred and eighty nine, to be exact. What it means in dynamic terms is quite dramatic. If a person spreads a gossip to just three others and the same is passed on by each of them to three others, and so on in succession, in just eighteen steps almost the entire population of India would share the spicy story. Note that if each step takes one hour, 90 per cent of the people hear the gossip for the first time only during the seventeenth and the eighteenth hours. Indeed during the whole of the first 80 per cent of the time, the process affects merely 11 per cent of the population. Even though each individual is partaking in the chain reaction exactly like all the others, who preceded him, that is, he receives information from one person and passes it on to three others, the social impact at a late stage of development hits like an avalanche. When we have a new infection, initially it is barely perceptible, but as the biological organism multiplies through successive generations, at a certain moment it suddenly permeates through the whole

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* Convocation Address to the Indian Institute of Technology, Madras, August 1, 1968.

system. You can observe this fascinating phenomena in making Da hi, or Yoghurt, or Thayir, as you call it here. In the same way, information, knowledge, innovation, people and things diverge rapidly and their collective effects appear suddenly even though the basic process in each case has proceeded over a long time span. When considering the social implications of technological change, one usually mentions the effects of the machine age on society through automation and imposed conformity. But these are trivial compared to the wider social implications of innovative man, who with curiosity, ingenuity and ambition, tries to reach out from his natural environment, and starts divergent processes.

In nature, left to itself, control is maintained through an ecological balance. Order is not imposed from above, but arises through the interaction of each unit with its environment in a dynamic equilibrium. On the other hand, inherent in a programme of accelerated development, there is a supression of some of the natural constraints which prevent divergence. And as the rate of innovation, of discovery and of everything else in the world gets faster and faster, so does the obsolescence of people and things become ever more acute. In contrast, biological development continues at its own pace. The child still requires nine months to develop in the womb. His life cycle of learning, of adolescence, as a house-holder and as an elder, who lays down the law, remains essentially unchanged. The situation is aggravated because of the increase in the life span of the human being. The contradiction between desired longivity and a world of increasing change is obvious. An inevitable result of all this is the disillusionment of the young concerning the understanding and behaviour of the middle aged and the old. Equally serious is the inability of those who wield power and influence over world affairs to adopt values and behaviour, inherent in an order where accelerating change, rather than stability, is dominant.

I suggest that today we witness a crisis of obsolescence. The qualitative change which has occurred in the last decade with the development of atomic energy, with the exploration and use of space, with the advent of electronics and computer sciences, is a manifestation of the divergent human function which has suddenly overtaken the world. What we have witnessed so far, dramatic as it is, is probably pedestrian compared to what we can expect in the future. We have heard of the feasibility of areas of the earth's surface illuminated during the night with sunlight through giant reflectors attached to satellites. We have also heard of weather modification, by increasing precipitation of rain in certain regions through artificially seeding clouds. There has been a suggestion of putting into orbit a belt of dust particles over the equator such that it would change the distribution of solar energy penetrating to different regions of the earth. It is claimed that such a belt could reduce the heat in the tropics and scatter more to high latitudes, providing a temperate climate even in the polar regions. This has many frightening possibilities because the level of the oceans would rise and submerge many inhabited areas. New leads in biology and genetics

pursued relentlessly are creating situations with implications few have thought through. Population control using the pill has tied up into knots theologists, wishing to interpret the sayings of the holy books in terms of current needs of society and new concepts of life. Just as doctors are faced with the problem of determining what death is before spare parts surgery would be justified, international lawyers rack their brains to determine an objective criterion for identifying where air space ends and outer space begins in which national sovereignty does not exist.

Affairs in the 1960s are largely in the hands of those who were already grown up when the Second World War broke out. Their learning experience and their theoretical knowledge relates principally to a period when the world was qualitatively different. The concepts of national sovereignty, of international spheres of influence, and power politics of the classical type have hardly changed even though we are constantly watched from satellites in outer space above us, and our security is threatened not merely by hostile neighbours, but by the actions and indiscretions of distant powers. What is the relevance of foreign bases in the context of long range missiles and nuclear submarines lurking unseen and silent on ocean floors? Is the Indian Ocean Indian any longer?

How shall we preserve democratic States where the media of mass communications provide means of instantly reaching downwards from centres of authority, but, short of public agitation, there is no authorised channel for the reverse feed back for controlling the political system between elections? What should be the goals of education in a world of obsolescence?

We find ourselves largely unprepared to meet the new situation. In real life, it makes a lot of difference how we view these occurrences. We have the situation in India, in common with many other countries, of students challenging the authority of Universities and of the establishment. Those who assume that the students are indisciplined and wayward, suggest that getting them involved in some activity such as the N.C.C. would set matters right. On the other hand, if one regards protests of students at Columbia, at Sorbonne and at Banaras as manifestations of a deeper malaise of society, the powers that be would introspect rather than preach.

There is no easy solution. But there is, I believe, much that we can learn from an analogue that we find in the peaceful applications of atomic energy more precisely, in the technique of extracting energy liberated in the fission of uranium. As is well-known, when an atom of the **235** isotope of uranium is hit by neutrons, it has a tendency to split into two lighter atoms, the combined weight of the splinters being less than the weight of the original atom. In the process of fission, not only is the difference of mass liberated as energy, but additional neutrons are released. When these neutrons hit other fissile atoms, a chain reaction occurs and the process can continue like the divergent spread of a gossip. We require a

critical mass of uranium before the chain can be self-sustaining and indeed when there is no other control device, the mass explodes through the sudden liberation of a large amount of energy on reaching criticality. This is what constitutes an atom bomb based on fission. When we wish to extract useful power out of the self-sustaining chain reaction of fission, we have to prevent the divergent release of neutrons, and of energy in the mass of the system. This needs the establishment of a large number of control loops which constantly and simultaneously sample the level of the reaction at various points of the reacting volume and sensitively adjust the position of neutron absorbers, strategically placed at various positions in the core of the reactor. Divergent trends are almost instantly compensated. An operators can shut down the reactor by pushing neutron absorbers into the core. But no reactor can be maintained in a steady state of self-sustained activity, necessary for providing useful energy, on the basis of exclusive reliance on gross controls operated with imperfect feed back loops. Indeed the control of potentially divergent systems relies on sensitive information loops which operate quickly in response to minute changes of activity.

What can we learn from this analogue in the social context? That control of the divergent human function cannot be maintained through the macro system of a super government. We need a system which permits an infinite number of micro control loops spread through the fabric of society. An authoritative regime can inhibit the divergent human function, but only at the cost of inhibiting development itself. Ironically, free societies are the ones which are most prone to the social impact of run away divergencies. It is in such free societies that the power of the super State, the super authority in education and for developmental tasks, is most difficult to sustain. I am intrigued by how closely this line of thinking brings us to Vinaobaji's and Jayaprakash's ideas on social and political organisation.

We are faced with the problem of the divergent human function manifesting itself on the world scene, while in India we are still trying to shake ourselves free from poverty. We have, I believe, to create a social system and a pattern of development which is based not on monolithic organisations operating impersonally at an all India level or even at the level of the States, but in units, where the feed back loop has high fidelity communication and a quick response. I am convinced, for instance, that our education system would immeasurably benefit if it were liberated from the monopolistic privileges under which Universities take hold of all educational matters at a certain level in allotted territories. There is no way in which a University Grants Commission or an affiliating University can ensure educational standards. In the ultimate analysis, it is only the teacher in the class-room that can do anything in the matter. He has to be provided the freedom to innovate in education in a changing world and, for this innovation, he has to receive the trust of those who back him up. I would suggest that the most effective development of education can take place only when the teacher, the student, his parents and the outside

environment can interact with one another, in a series of feed back loops, free from regimentation and irrelevant theories and principles preached from the top.

Engineers look forward to play a meaningful role in society. We are nationally poised to formulate a new Five Year Plan for development. Economists in the past have been prone to equate investments in hard facilities as necessary for economic growth. ' This is often true, but in the present context, it is largely fallacious. Twenty years after independence, we find ourselves with a broad infra-structure of plants and facilities in the engineering industries which are largely under-utilised. We also find a number of well established laboratories, without clear-cut developmental tasks which are meaningful in terms of national priorities. What is needed now is a major investment in design and developmental effort directed at indigenous capability for carefully chosen tasks, which are important to us. As an example, I might cite a good transportation system; providing an inexpensive scooter or a cheap car; a mass communication system which brings television to every village in a decade; inexpensive power through the countryside based on optimisation of grids, with a combination of hydro-electric, atomic and thermal units; a defence system based largely on hardware related to our own strategic needs rather than one which is reliant on what our friends overseas choose to sell us, gift to us or help produce udder their know-how We can identify sub-systems, under each of these major tasks and we can create design and development groups, which can operate with a wide measure of autonomy They will require trust to be able to innovate: All this is not a pipe dream. I hone we have the good fortune of realising these programmes before divergent functions in our society blow asunder all that we cherish.

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Distr.
LIMITED

A/CONF.34/L.3 17 August 1968

ORIGINAL: ENGLISH

United Nations Conference on the Exploration and Peaceful Uses of Outer Space

ADDRESS BY DR. VIKRAM A. SARABHAI,
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AND VICE-PRESIDENT AND SCIENTIFIC CHAIRMAN
OP THE UNITED NATIONS CONFERENCE ON THE
EXPLORATION AND PEACEFUL USES OF OUTER SPACE
VIENNA, 14 AUGUST 1968

Mr. President, Under Secretary-General of the United Nations, Your Excellencies, Distinguished Delegates to the Conference, Ladies and Gentlemen,

This Conference, which marks the completion of a decade of the space age, is appropriately held at the initiative of the United Nations Committee on the Peaceful Uses of Outer Space and through the directive of the General Assembly. The uses of outer space, peaceful as well as military, are already bringing about a qualitative change in our lives and can be expected to play an even more Significant role in the future. The establishment of the United Nations Committee on the Peaceful Uses of Outer Space is indeed a recognition of this fact. Austria, our host country, has provided Chairmen for this important Committee, who have guided its affairs with leadership, understanding and tact. The holding of this Conference in Vienna today is largely the result of the untiring efforts and initiative of its Chairman, who we are fortunate to have today as our President. May I, Sir, on behalf of all the participants offer felicitations to you? I thank you for making this Conference possible and for bringing us to this lovely city.

I deem it a great privilege to have been nominated Vice-President and Scientific Chairman of this Conference. I trust that through my work I will be able to convey my appreciation of the honour you have done me.

India has established at Thumba with the active co-operation of the United States, the Soviet Union and France an equatorial sounding rocket range. This international facility has received United Nations sponsorship and is a unique example of nations following different political paths joining resources for promoting the peaceful uses of outer space. Modest as that experiment is, I believe it provides a model of great significance to the future.

So too is the experimental satellite communications earth station at Ahmedabad which has received support from the United Nations Development Fund and the International Telecommunications Union, and now runs an international training centre. United Nations assistance to the project, pledged several years ago, was a forward-looking departure from established practice in such matters. For it involves a recognition of the proposition that advanced projects, even ones dealing with outer space, can be of relevance to the real problems of a developing nation. The trust displayed by the concerned international agencies in accepting our interest as a serious one has, I believe, been fully borne out by subsequent events. India is now putting up a commercial earth terminal for satellite communications with system's responsibility and project execution undertaken by its own nationals who have acquired competence and self-confidence through participation in the earlier project. A 98-foot fully steerable antenna is also being fabricated in India. Moreover, equal benefits from the project flow to the nationals of the many countries, forming more than half of the trainees in the courses given at Ahmedabad.

I believe that several uses of outer space can be of immense benefit to developing nations wishing to advance economically and socially. Indeed without them it is difficult to see how they can hold their own in a shrinking world. I shall try to outline today some of the objectives of space research and some implications of the practical uses of outer space. Drawing on experience gained through professional involvement and management responsibility for atomic energy and space research and their applications to tasks of national development in India, I will share with you some of my thinking on the problems encountered in realizing practical benefits from advanced technologies. Finally, *I* will examine the type of international collaboration that I believe is required before a large number of nations in the world, developing countries as well as small advanced countries, can partake in the benefits of outer space.

The sun provides the driving force for almost everything that happens on earth; weather, rivers, vegetation, fossil fuels and of course life itself. But in contrast to the apparent constancy of the sun and the complete dependability of sunrise and sunset, we experience a capriciously variable environment, the fury of hurricanes and lashing ocean waves, droughts and floods,

starvation one year and bumper crops another, and uncertain radio communications. The natural scientist looking for the subtle links through which the sun affects the earth and our lives has at last acquired in the exploration of space a dramatic new capability for study. He has discovered that in the solar system, the space separating the sun and the planets is filled with extremely rarified matter constantly flowing outwards from the sun with a velocity of about 300 to 500 kilometres per second. The solar wind as it is called, carries with it the sun's magnetic field, and the regime around planets is broadly analogous to what happens when a big boulder sticks out in the middle of a swiftly flowing stream of water. The sun itself is not placid, and the surface is not, uniform. Apart from beauty spots showing up every now and then, it throbs like a boiling cauldron and it experiences storms of great violence.

There is another major interest in exploring space. The earth's crust and the lower atmosphere have temperatures and densities such that electromagnetic and hydrodynamic phenomenon function largely independently of each other. But this state is rather special and does not commonly occur in the universe. Even on earth it does not occur in the molten core or if we go upwards beyond 80 or 100 kilometres. In the sun and the stars as well as in inter-stellar and inter-planetary space, electromagnetic and hydrodynamic behaviour are intimately linked. In consequence fluids behave in a manner unfamiliar to us and there are many open questions for which laboratory experiments are of limited use since they do not simulate what happens on a cosmical scale. Space research has at last made direct experimentation possible in the magnetosphere of the earth and in inter-planetary space.

A third important scientific objective has been to view the universe, the galaxy and the solar system through a wide window. The blanket of the atmosphere under which we live eliminates all but a tiny fraction of the broad spectrum of electro—magnetic radiations and particles which impinge on the earth carrying with them information about the sources where they originated and the properties of the media through which they have traversed. Depending merely on observations made with earth bound instruments to picture the universe, and understand cosmology is like the attempt of a blindfolded man to describe an

elephant by touching the trunk and the legs of the animal. Through space research we have now become aware of X-rays not only from the sun but from strange distant objects in the galaxy. The intensity often changes in a most interesting manner within a short period of a few days. Planetary research is helping us understand the origin of the solar system and the crucial question of the existence of extraterrestrial life. We shall hear more about these exciting discoveries during the Conference. But I wish here to pay a tribute to the scientists and engineers who have pioneered in this field. Particular mention is appropriately made of the outstanding contributions of the Soviet Union and the United States.

Technological advances which have provided weightlessness and permitted man to free himself from the solid earth have opened a vast field of human knowledge where, as yet, we are only scratching on the surface. They have also produced major qualitative changes of social and political significance, I suggest that the practical benefits are hot realized in full measure unless the applications are undertaken side by side with the serious pursuit of activities which go beyond installing black boxes. They need the investment and commitment of nationals of the country in related fundamental and applied sciences and innovative tasks. Moreover, in realizing these benefits, the most difficult problems are neither technological nor economic, but related to human and social factors.

We should note that the peaceful uses of outer space, as for example in the field of telecommunications or meteorology, involve developments along advancing frontiers of science and technology. They produce rapid obsolescence not only of hardware, but established systems of organization, of administrators and technicians responsible for providing national services. The full benefits of outer space can be realized only when nationally and internationally an appropriate culture can be created. I recall our own experience in establishing a modest programme for studying equatorial aeronomy with sounding rockets from Thumba. It became quite obvious that we could succeed in executing such a programme only when the necessary social change occurred to permit an interdisciplinary group of specialists and innovators to work competently for a well-defined common objective.

We shall lose perspective in interpreting the social implications of space science and technology if we fail to recognize that those developments form an important part, of a wider set of diverging human functions. A characteristic property of such functions is best illustrated by understanding the meaning of a number expressed as a power, for instance, three raised to the power of eighteen, which is about 390 million. In dynamic terms it illustrates a very interesting feature of divergent functions. If a man were to spread a gossip to three other persons and each of these three would convey it to three others and so on, it would take just 18 steps for all the people in a nation as large as India to know the spicy story. Note that if each step takes one hour, ninety per cent of the people get to learn the story only during the. last two, hours, the 17th and the 18th hour. Indeed during eighty per cent of the time the process affects only 10 per cent of the population, all things which involve the human element, for example, population, knowledge and innovation, have this characteristic property. Like biological infection which propagates almost unnoticed through many steps but makes its onslaught felt all of a sudden, so too, the social impact of innovative man has hit society like an avalanche. Scientific advances and technological innovations along with their social and political implications have suddenly overtaken the pace of the human life cycle and produced a crisis of obsolescence.

Many political implications arise from the military uses of outer space and surveillance by satellites. National security and sovereignty have been eroded while privacy has been encroached upon. When security is threatened not by a hostile neighbour but by the actions of distant powers, what is the relevance of traditional concepts in international relations such as spheres of influence and power politics, of bases and alliances? Obsolescence of thinking and patterns of behaviour in international affairs poses today a most serious threat to our survival.

The greatest cost/effectivness of the uses of outer space occur through large scale applications rather than those of limited scope. A communication satellite can most effectively serve communities dispersed over large areas. Meteorological applications of satellites are likewise most relevant for a

global system like the world weather Watch. This creates two types of problems, both of which are particularly acute to developing nations and to small advanced nations. In the first place there is the difficulty of providing on an exclusively national basis either the effective utilization or the resources for deploying the new system. Generally in developing countries, the tele-communications traffic is not large enough to permit effective utilization of a satellite; the national meteorological organization is not equipped to make use of world wide data for improved forecasting or to contemplate projects for weather modification. Under these circumstances, the benefits of the uses of outer space truly accrue only through international co-operation based on inter-dependence. Indeed the situation here brings out dramatically a feature which is not peculiar to outer space but to many other fields of technological development; of monolithic technological systems created to serve social groups with diverse cultures, history and political objectives.

Space research shares with the growth of electronics and of atomic energy the characteristic that its progress has depended very crucially on the interplay of fundamental sciences with technology. Just as solid state physics has contributed to electronics and nuclear physics to reactor technology, several fundamental sciences have contributed to space research. This has the important consequence of providing to the practical applications an inbuilt culture of international science - propagating beyond national frontiers, permitting two way communications not constricted by commercial considerations nor even subject to effective containment on national considerations.

This Conference is to lay special emphasis on the benefits which can be derived by developing countries from participation in the peaceful uses of outer space. The primary concern of such nations must presumably be social and economic development, and indeed during the last 20 years, we have seen an increasing realization, at least intellectually, of the grave threat that exists to the security of the world through wide disparities in the standards of living in different regions. But a relevant question to ask in this context is why in spite of much that has been attempted bilaterally, regionally and through international agencies, the gap between the advanced and the developing nations has widened rather than decreased? In examining the question from a

different angle, I have asked myself the question why is India one of the most expensive poor countries? I could observe two important factors. First that since developing nations by definition start from a low economic base, their incremental growth, large as it might be when expressed per cent wise, is intrinsically small compared to the incremental annual growth even of much smaller economically advanced nations. Thus, a developing nation following step by step approach towards progress is landed with units of small size, which do not permit the economic deployment of new technologies. Through undertaking ventures of uneconomic size with obsolete technologies, the race with advanced nations is lost before it is started. Indeed, if one continues to operate on this philosopy, financial and technical assistance from the advanced nations to the developing nations can only result in the frustration of the former and the increasing economic dependence of the latter.

A positive approach out of this predicament seems to lie in finding solutions where the particular disadvantage of developing nations, which is that they have little to build on, is made an asset rather than a liability. I suggest that it is necessary for them to develop competence in advanced technologies and to deploy them for the solution of their own particular problems not for prestige, but based on sound technical and economic evaluation involving commitment of real resources. They would most likely discover that the traditional approach of planning to provide things like electric power or telecommunication services for a national infrastructure, based on projections of growth from past experience leads to a dead end. They will also discover that an alternative approach lies in creating consumption centres alongside facilities for supply; that as in the case of large nuclear power stations serving agro-industrial complexes, synchronous satellites could be planned in the context of a programme to be simultaneously undertaken for direct broadcast television to the entire countryside. Indeed they would discover that there is a totality about the process of development which involves not only advanced technology and hardware but imaginative planning of supply and consumption centres, of social organization and management, to leapfrog from a state of backwardness and poverty.

Developing nations which have a large area and big population, such as India, have the possibility of effectively utilizing space communications systems for national needs. Compared to advanced nations such as the USA, Canada and the USSR, they have indeed an advantage through not having an existing major investment in older technologies. For them the principal problem is of mobilizing resources and of developing them adequately. The most important input I regard in this exeicise is of course the human element of trained engineers, scientists and managers, of people who understand not only the technological but the social implications of the system which they wish to deploy. Developing nations differ widely in regard to existing human resources of the requisite type needed to partake in the peaceful uses of outer space. In India, for instance, when independence was achieved, there were in the country tens of thousands of engineers and scientists and several thousands abroad. The capability of such a country where scientific investigations dealing with meteorology, geomagnetism and astronomy have been conducted for more than 100 years and a sophisticated culture and tradition for learning exist, is quite different from that of developing countries with a much weaker professional base. True, that expressed as a per cent of population the number of professional scientists and engineers in countries, such as India are small; but in absolute terms they compare well with the numbers that are found in nations such as Germany, Italy or Japan. Moreover since advanced technologies require skilled personnel in large measure the situation is not different for advanced and developing countries. Under these circumstances, surely the developing countries with a professional base have an economic edge in a straight competitive situation.

At the moment, in India we are deeply interested and involved in an evaluation of the benefits that a synchronous satellite can provide for national needs of point to point communications, for mass communications through direct broadcast television to promote national integration as well as the economic development of isolated communities, for meteorological observations covering the vast Indian ocean and for assisting navigation. Just for one application, namely, the provision of broad-band communications for reaching through television half a million villages of India, it can be

shown that using satellites the investment would be only about a third of what would be required with conventional technologies. Where capital funds and foreign exchange are crucial bottlenecks, the deployment of a satellite communication system based on a largely indigenous effort in electronics can make all the difference to a national decision for adopting the most effective and persuasive means as yet available for mass communications. Indeed it is estimated that with an annual investment equivalent to about 40 million dollars one can provide community television to all the 560,000 villages in India over a five-year period. This would incidentally generate a strong industrial base in electronics providing employment to about 120,000 qualified scientists, engineers, technicians, managers and other administrative personnel. But before such programmes can be undertaken, there are formidable problems, which perhaps many developing countries would encounter.

First, we often meet with lack of self-confidence to pursue major tasks involving complex and unfamiliar technologies. There is also an in-built culture within which a major departure from existing well proven systems, and anything which is innovative in character is automatically regarded with suspicion. The administrative structure of Governments in many nations is dominated at the top not by technocrats but by professional administrators, lawyers or soldiers, who are hardly likely to provide. the insights, experience and the first hand knowledge of science and technology which are necessary at the decision making level. Moreover, advanced nations often play a negative role in their interaction with the developing countries. There is seduction by their political and commercial salesmen who dangle new gimmicks which they suggest should be imported rather than indigenous capability be developed and supported. There are those who preach as guardians of the economic well being of the developing nations that they must proceed step-by-step following the same process by which the nations themselves progressed. One is often told that such and such a thing is too sophisticated to be applied. This approach disregards what should perhaps be obvious, that when a problem is great, one: requires the most effective means available to deal with it.

One of the hardest questions to be faced in adopting a synchronous satellite for national needs, arises from the fact that many interested countries would not expect in the near future to have an independent capability for placing such a satellite in oroit. The nations advanced in space research have done much to extend the benefits of the peaceful uses of outer space to all countries, and one can reasonably count on their continued support. But the political implications of a national system dependent on foreign agencies for launching a satellite are complex. They are not negative in the present day world only in the context of the coming together of the national interest of the launcher and the user nations. As long as there is no effective mutuality or interdependence between the two, many nations left only with the ground segment would probably feel the need for some measure of redundant capability under complete national jurisdiction. There is great scope to-day to explore this structure of possible international systems which could provide credibility in increasing measure that the space segment could be relied upon even in the context of political and ideological differences amongst nations.

Perhaps collaborative participation of nations in the construction and operation of a launching system for the peaceful uses of outer space would be realised in the long run. The military overtones of a launcher development programme of course complicate the free transmittal of know-how of technology involved in these applications. But it is important to note a fundamental aspect of human development that knowledge cannot for long be contained within artificial boundaries and one has to learn to share and to control rather than I control harmful effects through withholding transfer of technology or knowledge. After all, the biggest secret regarding the atom bomb was let out when through the demonstration of the explosion over Hiroshima it became known to everybody that the device worked. Similarly, the biggest secret in space research became public property when the successful orbiting of the first Soviet satellite proved that this feat was possible. Thereafter, it is merely a question of time. Restrictions on the transfer of technologies which are involved in the peaceful uses of outer space merely jeopardise the security of the world through retarding the progress of nations.

A physicist is trained to accept that what is not possible in theory, not realisable in practice. This elementary experience can well be applied in planning international systems for promoting the peaceful uses of outer space; as indeed also for peaceful nuclear explosions. Those systems that do not provide full participation by all nations in all aspects of technology in which they are competent to partake in, are in my humble opinion not saleable, much less sustainable in the long run. Attempts to promote them merely poison international relations and the climate of co-operation. I hope that at this Conference fresh thinking on this subject will be generated. Unlike atomic energy for which there is a specialised agency of the United Nations with its headquarters in this city, there is for outer space in New York a separate division at the U.N. and there is also the U.N. Committee on the Peaceful Uses of Outer Space. The resources at the disposal of the outer space division are totally insufficient for it to perform an active role. I would earnestly urge that serious consideration be given to redefine its responsibilities and role providing appropriate back-up to stimulate on a continuing basis the understanding and the utilisation by all nations, of the uses of outer space. There is much scope for opening the doors to permit access to all of the advances in space technology. If this Conference is to the peaceful uses of outer space, what the first Atoms for Peace Conference was to atomic energy, the high expectations with which we are assembled here to-day would be fully realised.

UNITED NATIONS CONFERENCE ON THE EXPLORATION AND PEACEFUL USES OF OUTER SPACE

Summary of the Conference and Recommendations for initiatives

by

Dr Vikram A. Sarabhai, Chairman, Indian Atomic Energy Commission and Vice-President and Scientific Chairman of the United Nations Conference on the Exploration and Peaceful Uses of Outer Space .

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When I started preparing for this summing-up session I felt rather overwhelmed, because we have covered a vast canvas and heard so much of deep significance that it seemed difficult without an adequate passage of time really to do justice to it. But I believe that the ideas which have been presented here, and the many suggestions - those related to hard reality and some others which still appear to be in the realm of fantasy - have together enriched our experience at this Conference. The question has often been asked: can one afford to undertake space research? But I am sure there are many here like myself, who will ask: can anyone afford to ignore the applications of space research? One departs from the Conference with the conviction that applications of space research touch every facet of life and, in adopting them imaginatively and with understanding, nations have an opportunity to dedicate themselves to a meaningful task of direct relevance to their development. Indeed the total impact on national life can be dramatic.

I suggest that many delegates, when they return to their own countries, would find it worthwhile to once again look through some of the key papers presented here. It is not possible to name each one of them, but at the introductory session significant applications have been admirably summarised.

The Chairmen of the thematic sessions have lightened my task by summarising what happened at the sessions. I will devote my remarks to certain aspects not covered in their reports, particularly the group discussions, which I believe are an innovation for a United Nations Conference. These have provided a welcome opportunity for an exchange of ideas, so much so that while at the start we envisaged six group discussions, we ended up with nine. The last on legal affairs unhappily did not quite come off because it was set up without adequate preparation and I offer my regrets to the Chairman of the thematic session concerned for the confusion created.

I would now like to touch upon what I consider to be some noteworthy aspects of the conference. If I cannot do adequate justice to all points, it is because the time for reflection has been short and the material vast.

There was a great deal of discussion at the Conference on the regulatory functions which would be required if satellite communications are extensively used for all manner of national needs in telecommunications, including mass communications involving direct broadcast television. It was felt that regulatory problems would be different in various regions depending upon the existing level and sophistication of telecommunications and that the regulatory specifications established by ITU should permit

variations in different areas of the world to maximise the cost effectiveness of the telecommunications systems. It was also recognised that progress in the field is so rapid that regulatory bodies have to move much faster than is customary in considering new developments of great economic significance to nations. Suggestions have been made about a two-level international system for providing services related to satellite telecommunications. The need for reform of the existing set up of Intelsat was generally recognised, and indeed formal consultations are already proceeding for this purpose. Moreover, a new international system has been proposed. This has too many dimensions for me to deal with adequately at this time, but the subject has been keenly discussed, and when the reports of the group discussions are available, interesting ideas will be found in them for concrete action in the future,

It was established that the technique for direct broadcast of television, which involves high power in the transponder and a restricted radiated beam from the satellite is almost here. There is great overall saving in the cost of the system when use is made of satellites with high effective radiated power. The question of obsolescence of existing satellites also came out, because during their effective life of perhaps five to ten years, they are overtaken by developments in technology. In consequence, an important question arises as to their replacement prior to the completion of their useful time of operation to make possible the deployment of newer techniques. It is a hard decision to make, but will have to be faced, taking into consideration a reduction of overall systems cost, particularly of ground terminals. It would be appropriate if an international body such as Intelsat sponsors research and development on a significant scale to make possible systems cost reduction at the earliest possible opportunity. There was great interest in trying out the implications of transmission frequencies from satellites in the 1 and the 10 G/c regions for direct broadcast.

In the discussion on meteorology, it was noted that in most countries the practical use of meteorology is currently made most effectively by aviation. It was emphasised that to derive wider benefits, nations would need to devote much greater effort than hitherto on meteorology applied to medium and long range weather forecasting and weather modification schemes. It was urged that nations would be well advised to invest in such programmes of benefit to their economies.

Automatic Picture Transmission (APT) came out as a programme of great importance and interest to a large number of countries and individuals. It has occurred to me that if modest units are widely installed, they could perhaps also be used to receive charts of global meteorological conditions prepared at the World Weather Watch Centres. I am intrigued by the possibility of the dual use of the system to improve the quality of local forecasting.

When we came to Vienna, we thought that the areas of most immediate practical applications would be communications, meteorology and navigation,

in that order. But one of the most striking things to emerge has been appreciation of the great potentiality of remote sensing devices, capable of providing large scale practical benefits. One of the group discussions considered the cost effectiveness of these techniques, and it was pointed out that there is a high cost benefit ratio, which, for example, in cartography, can be as much as 18:1. The time has come to interest meteorologists, hydrologists, surveyors, agricultural specialists and other groups in such programmes. The Chairman of the thematic session summarised the consensus that aircraft could initially be used because of their comparatively low cost. There is need, to begin with, to understand problems of interpretation. Remote sensing cannot replace man on ground, but can direct man's efforts on ground to be more efficient.

We had an interesting group discussion on education. The benefits of television for education are well recognised, but it was noted that television is not a substitute for the teacher but a powerful means of making him more effective. The main problems are not technical but pedagogical. They are principally the identification of people who could be benefited by education through television, the motivation of people to be receptive to the benefits of education, the creation of suitable programmes to maintain continuous interest, the selection of monitors to conduct the programmes, the special problems when a country is multilingual, and the question of feed-back from subjects on effectiveness of the programmes and its evaluation. There is great need to develop software for educational and instructional television.

The role of the United Nations, its international agencies, and international cooperation were discussed at three most interesting group discussions. The thematic sessions on biology and medicine, on non-space applications, and education recognized that there was need for United Nations programmes, that would provide training in these three areas. It has been stated that Ivory Coast, Madagascar, Kenya and Ghana are ready to cooperate in a United Nations training project. The need to increase the cost effectiveness of United Nations Agencies and programmes was repeatedly voiced. It was noted that the success of multinational programmes depended on credibility in the stated purpose. The Thumba Equatorial Rocket Launching Station in India is a good example of international cooperation where bilateral collaborative effort under the umbrella of United Nations sponsorship had worked very effectively.

Bilateral cooperation often offers the most advantageous way for getting on with work. It was recognized that international cooperation works best when concerned with specific projects, and also that there are a number of ways in which projects are initiated and sustained and a rigid approach is inappropriate.

The activities of the United Nations were discussed at *a* number of sessions. At present we have the Outer Space Committee, its two sub-committees and the Outer Space Division of the United Nations. It was recognized that more would have to be done, and while the question of an

independent Agency was raised, there was much emphasis on strengthening activities within the framework of the Outer Space Division with scope to take initiative. On the professional side, the Division could be augmented by specialists seconded for a limited duration of time by member States.

I would like to invite attention of the Conference to experience in the International Council of Scientific Unions (ICSU). When space research became possible, there was a need to bring together scientists interested in various disciplines and COSPAR was formed by ICSU, involving various bodies such as the Union of Geophysics and Geodesy, of Astronomy, of Radio and so on. We have in the United Nations various bodies such as ITU, WMO, UNESCO, FAO, charged with responsibilities in specific areas of applications. It has occurred to me forcefully at this meeting that there is no group or body which can take initiative on a continuing basis for promoting the applications of space, particularly in developing countries. There is a need at the United Nations level to look at the present and the forward-looking problems of applications of the uses of outer space in a variety of fields. I have suggested that an Applications Resource Group of ten or twelve specialists, with an advisory role and meeting perhaps once a year might be quite effective to generate new ideas that might lead to the tying -in of the efforts done by various agencies. Moreover, there is good scope for some projects to be supported jointly by two or more specialised agencies, as is being done by the Atomic Energy Agency and the Food and Agriculture Organisation. The United Nations Outer Space Division could generate a great deal of interest and understanding by arranging specialist panel meetings on specific topics on lines the IAEA has followed so effectively. These panel meetings, perhaps no more than four per year of fifteen or twenty people, could produce documentation and new ideas on specific applications, which could then be distributed widely. These meetings could be held in different parts of the world in order to generate local interest. And then there is the need for a number of scholarships for nationals of developing countries. I feel that one would need perhaps a hundred per year, for training related to specific applications which a nation wants to undertake. There should be some funds available for governments committed to certain projects to be able to send their people to institutions run by nations advanced in the subjects concerned. The funds should support travel expenses and maintenance during a period of six months to a year.

Another programme of some importance which the United Nations could consider would be to undertake survey missions, on request, from countries or groups of countries to explore the potential of certain specific techniques within the context of local situations. There is need for a modest programme of technical assistance for developing countries to set up facilities like APT. If a country wants to construct an APT unit itself, there should be some funds available for taking a scientist or engineer to a place, where he could make the first unit. For example, we will be very happy to provide at our Space Science and Technology Centre in India facilities and assistance to those wishing to build such units themselves and then taking them back with them. This type of technical assistance should be

geared to specific programmes of immediate benefit where the country itself is interested in making a commitment. United Nations sponsorship, like at Thumba, to multinational cooperative projects for space applications might be very helpful in providing an umbrella for bilateral cooperation.

I have tried to estimate what all this adds up to in financial terms. It seems that an allocation within the United Nations of something like half a million dollars a year may be required to start with. This might grow to one or two million dollars in three years. Independently of the activities of the specialised agencies, this would be quite a significant added input by the United Nations, through its outer Space Division, to promote the peaceful uses of outer space.

There is yet another need of particular relevance to developing countries to which I would like to refer to. There are many countries like Brazil, Argentina, some States in Africa, Indonesia, Pakistan, India, Australia and Canada, which have territories vast enough or regions which require to be covered by telecommunications, which could use part or all of a synchronous satellite capability exclusively leased for their own national needs. There are also many smaller countries, in Europe, for instance, where need exists for regional telecommunications. Local control of fully leased channels should not be inconsistent with international obligations and control of the global satellite telecommunication system. At least as far as developing countries are concerned, I feel much could be gained if national use of Intelsat facilities, for instance, could be based on fulltime leasing of channels for which they can pay in local currency for the first twenty years or so, since one great difficulty for them would be payment in foreign exchange for a national service. The financial impact of this would be quite small compared to the magnitude of world technical assistance tody which is probably in the region of $ 3 - 5 billion a year, and expenditure on the peaceful uses of outer space which is also of that order. If, internationally, something like a hundred million dollars a year are used to augment the facilities of international satellites, for example through Intelsat, and channels could be hired fulltime in local currency for the time being, providing low-cost utilisation of a complete satellite, the expenditure by an agency such as UNDP would amount to something like 2 per cent per annum of the volume of all aid or expenditure on space research. It seems to me that with the promise that outer space is now presenting, this type of international support would be well worthwhile. Most importantly, it would eliminate the investment today by developing countries in obsolete technologies and permit a drastic reduction of satellite communication tariffs through their full utilisation which is not possible immediately in many regions on international traffic by itself.

It would be appropriate if the reports of this Conference are first considered by the Scientific and Technical Sub-Committee of the Outer Space Committee. I would hope that this Committee could look at all aspects in a detailed manner and come up with concrete proposals which the Outer Space Committee and the United Nations could hopefully adopt. I feel that one of the important objectives of this Conference would not be fulfilled if the presentations given here are not available to a wider audience of policy

makers through pamphlets and effective audio-visual media. It is important to be able to disseminate information in various regions to the many people who could not come to Vienna. I hope that the United Nations will allocate adequate resources to make this possible without delay.

Finally, Sir, I have the pleasant duty of thanking you and the host country. A most important ingredient of this Conference has been the relaxed atmosphere in which we have approached our task, and to no small extent this is due to the very generous hospitality afforded by Austria. I want to say on behalf of all of us how much we have appreciated this. ME President, I referred earlier to your personal contribution. But for your very active initiative through these last two or three years this Conference would certainly not have taken place. Such a Conference cannot succeed without the inputs which the delegations of nations bring to it. Various delegations, and particularly nations which have developed space research effectively, have been most generous in sharing information and experiences. This sets a very good precedent for the future. I am sure that in this achievement the main objective of this Conference has been realized. I wish to thank the United Nations Secretariat - Mr. Abdel-Ghani and his associates, the scientific secretaries who have taken time off from their countries to come to work for the Conference, the OPI, the Conference officers and of course the interpreters, without whom I do not know how this Conference could have succeeded.

I wish to thank all delegates personally for the kindness, thought and courtesy that I have received in my job, which I hope has been to your satisfaction.

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ADDRESS BY DR. VIKRAM A. SARABHAI, CHAIRMAN, INDIAN ATOMIC ENERGY COMMISSION DURING THE 12TH GENERAL CONFERENCE OF THE I. A. E. A. IN VIENNA ON SEPTEMBER 26, 1968.

Mr President, it is a great privilege to lead my delegation to this General Conference of the Agency. I wish to congratulate you as a very old friend, as a colleague in the field of cosmic rays, and I wish to tell you how much pleasure it has given me and my delegation that you are occupying this high position. It also gives me some comfort that in fishing outside our own territorial waters I am in good company with you, Sir. I wish to congratulate here the Director General and the staff of the Agency for another excellent year of progress and I wish to welcome our new members, Liechtenstein, Niger and Zambia, and look forward to cooperating with them in promoting the ideals of this Agency.

2. This year we have circulated beforehand the account of atomic energy developments in India and this makes my task easier at this session. I would like however to highlight a phase which is of some significance to all countries, and particularly to developing nations. Having spent 15 to 20 years in establishing the ground base for atomic energy, India is now exploring in some detail, the applications of atomic energy in various fields of national development and apart from power and agriculture about which I shall discuss in much greater detail in my lecture this afternoon. I wish to draw pointed attention to the very great scope which seems to exist in the irradiation of potatoes and onions, crops which are of great importance in the tropics.

3. Our own evaluation shows that in this field there are very large returns to be had and I am sure that with the facility which we have put up in India in collaboration with Canada, which we call the Fiply facility, much scope exists not only for making trials in our own country but also for making this knowledge and experience available to all those who are interested in it. We have been very fortunate in our programme in having warm and friendly relations and co-operation with many countries. My distinguished colleague from Australia mentioned yesterday the details of the projects with which we are jointly involved. I wish to reciprocate our warm feelings to him about our common projects. So too, with the Philippines with which we have had a very successful project, known as the India - Philippines Agency Project.

4. Then there are the atomic energy commissions of many countries. I would name particularly Canada, France, the USSR, the UK and the USA who have actively collaborated with us in many areas and we cherish our relationships with them. In the field of nuclear power, we feel that there is a very big potential, as I will again discuss in detail this afternoon, and I would like to endorse a suggestion which has been made elsewhere that international organizations such as the UN Development Fund and the International Bank for Reconstruction and Development may well evaluate

for themselves the scope of this important area for developing countries. I hope that the Agency's expertise would be available to these bodies to put the matter in the right perspective. I do feel that in many cases, financial considerations would be a serious impediment to the utilization of these new technologies.

5. I was listening with great interest to the statement of the Director General at this Conference yesterday. I must admit some concern about a particular quotation which I would like to read here:

> "When the NPT is in force there will have to be a shift of emphasis in the work of the IAEA. More weight will have to be given to the control functions. I hope that the Agency will still remain a technical organization, although it is inevitable that it will become much more exposed to the political situation in the world".

In another context, it has been mentioned, and I again quote:

> ". . that the Agency's safeguards system would have to be adapted to the requirements of article 3 of the NPT."

I would like to express some concern that these sentiments should have been expressed, because the Agency's primary role has been clearly stated in its Statute and in its Articles, and the control function, which is an essential and a necessary function, is an adjunct to the more positive function of promoting the peaceful uses of atomic energy. I believe that one has to particularly safeguard the Agency's effort in the more positive, directions, because without this the regulatory function will become rather meaningless for the many countries which have still to taste the fruits of the benefits of atomic energy.

6. Sir, I would like to quote the relevant article in our Statute. It says:

> "In carrying out its functions the Agency shall not make assistance to Members subject to any political, economic, military or other conditions incompatible with the provisions of this Statute."

In another connexion, it says:

> "The Agency shall allocate its resources in such a manner as to secure efficient utilization and the greatest possible general benefits in all areas in the world bearing in mind the special needs of the under-developed areas of the world."

I do not doubt for a moment that you cherish all these things that are embodied in the Statue before us. But I would like to express my own personal view here that unless this Agency - and this will require self-restraint on the part of every one - can make a conscious effort to reject

the impinging of political pressures and political overtones into our activities, we shall wreck the very wonderful edifice which has been created with so much trouble over a long period of years.

7. The Agency's safeguards system certainly requires much reform, and we endorse efforts to this end. We hope that the document on Safeguards for reprocessing plants will be brought in line with the revisions that have recently been done for the fuel fabrication document. It seems to me that the most important missing link in this whole chain of Agency documents on safeguards is the one relating to isotope enrichment. It seems to me that the efforts being made now to get detailed discussions on this subject are overdue, and I wish great success to the efforts, to see that we make progress regarding isotope enrichment. In the peaceful uses of atomic energy I have no doubt that isotope enrichment will play a very useful and important role. Unless we tackle this problem before it becomes even more difficult, we are likely to be led into more complications.

8. The most important ingredient of Agency's activities I would suggest are those provided in Article 3 1 which makes it very clear that all Agency services and activities are provided on request. I hope that in all the things we do we shall continue fully to maintain the spirit of this Article. I believe that the Agency is fully competent to undertake all services requested of it by those who signed the Non-Proliferation Treaty, and that there is no need for a new international body. Indeed, Articles 8, 9 and 10 in the Agency's Statute which refer to information on materials, and to services, equipment and facilities are fully com prehensive in our opinion and can already form the basis for providing all the services which one can think might be required to fulfil any of the obligations which those who have signed the Treaty require the Agency to provide for them.

9. There has been a legitimate concern about the representative character of the Board, and we believe that there is reality in the feeling that the current situation reflects the need for some change or reform in the composition of the representation on this Board. We believe that it would be a legitimate exercise on which thinking would be required I cannot help feeling that this is not going to be an easy process, because the considerations on which representation is given have been evolved after a great deal of negotiation and have stood the test of time. In the new thinking that we do, much would be gained by keeping some of these older principles still alive while providing a more enlarged represent-ation. But I would suggest that this is something on which thinking could well begin.

10. The peaceful applications of nuclear explosions is a matter which has exercised much thought in recent times. About a month ago when I was scientific chairman of an outer space conference here I made the following observation, which I would like to quote. I said

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> "The military overtones of a satellite launcher development programme of course complicate the free transmittal of know-how of technology involved in these applications. But it is important to note a fundamental aspect of human development that knowledge cannot for long be contained within artificial boundaries and one has to learn and to control rather than control harmful effects through with-holding transfer of technology or knowledge. After all, the biggest secret regarding atomic bomb was let out when through the demonstration of the explosion over Hiroshima it became known to everybody that the device worked. Similarly, the biggest secret in space research became public property when the successful orbiting of the first Soviet satellite proved that this feat was possible. Thereafter, it is merely a question of time. Restrictions on the transfer of technologies which are involved in the peaceful uses of outer space merely jeopardise the security of the world through retarding the progress of nations. A physicist is trained to accept that what is not possible in theory is not realisable in practice. This elementary experience can well be applied in planning international systems for promoting the peaceful uses of outer space, as indeed also for peaceful nuclear explosions. Those systems that do not provide full participation by all nations in all aspects of technology in which they are competent to partake, are in my humble opinion not saleable, much less substainable in the long run. Attempts to promote such systems merely poison international relations and the climate of co-operation"

I have quoted this because this is an aspect which I feel is a very fundamental one, growing from our understanding of science and technology. But I would like to say that I regard the Agency as the appropriate body to perform the regulatory functions which will undoubtedly be required for the conduct of peaceful nuclear explosions. I think, in this whole debate about the role of international agencies, one would have to distinguish the necessity of a regulatory body which would permit such explosions under a regime under either a partial or a complete test ban treaty and another agency which might assist nations on request to provide the services which are necessary. I would hope that more clarification on the subject consistent with the Agency's statute will take place in the coming months and that we shall have a clearer idea of the lines on which this matter can be dealt with.

11. I come now to some observations on the Agency's Budget. To me, the resources position and the increasing responsibilities cause considerable anxiety, not because one is not willing to undertake them but because there doesn't seem to be a clearcut explicit exercise undertaken at the Board level, to look at this problem in all its dimensions. It would seem to me that we might look at this problem for the next five years, because almost

every atomic power station which is likely to be built during the next five years has already been committed now. One has a very clear idea of what is the magnitude of the problem which is likely to be faced during the next five years. It seems to me that one could define the alternative aspects of safeguards procedures which should be undertaken and estimate the relative cost of each one. It might be that one could arrive at a principle in which safeguards will be carried out at a certain level of operation on a normal basis, but that the Agency has the power and authority to conduct more detailed safeguards inspections, as may be required if the need arises, so that without burdening the Agency's budget and procedures with the required severity of safeguards inspections one could leave certain flexibility to the Agency inspectorate to undertake detailed inspections as required under certain circumstances.

12. I feel that a separate fund for safeguards organization of the Agency would be required, and that it would be equitable if contributions to this fund are made on the basis of installed nuclear power of nations rather than any other. Ore of the great problems that would arise if this is done on the basis of the normal budget would be that developing nations which are far from having nuclear power, would already start paying a contribution in terms of foreign exchange, for services which are not really originating from developments from which they have reaped the benefit. It would be more equitable if those who are reaping the benefit from the peaceful uses of atomic energy had this as a charge. It would be a small one, which would not make a significant difference to the economic picture of that particular benefit.

13. I am very glad that the Agency is now exploring the possibility of obtaining analytical and other services which it requires, from various national agencies. I was sorry to learn from the Director General's comments that the response had not been very satisfactory, and I would hope that more national laboratories in various parts of the world would come forward to provide to the Agency, analytical and other services, which would reduce the burden on the Agency's budget.

14. Technical assistance, I still believe, is one of the most important and positive aspects of the Agency's activities, and we feel that unless some way is found for providing more technical assistance rather than less, as has been happening during the last few years, there is no immediate possibility of a large number of developing nations really getting into this field. At Tarapur we have been having trainees from a large number of countries who have come to see the starting of operations, and I would like to offer here similar facilities which we hope to provide also in the irradiation of food.

15. It is a pleasure again to pledge a voluntary contribution of $ 35, 000 in non-convertible rupees to the Agency, and I would like to close sir, by pledging my nation's wholehearted and complete support to the Agency and all its activities, and wish you well in the years to come.

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HOW GREEN IS OUR REVOLUTION*

by Vikram Sarabhai

I deem it a great privilege to be invited to deliver the First Lal Bahadur Shastri Memorial Lecture of the Indian Agricultural Research Institute. Lal Bahadurji was at the helm of affairs at one of the most critical phases in Indian history since Independence. While he was creating a new style of national leadership after the death of Jawaharlalji, his Government had to mobilise the nation to repulse a vicious military invasion on its Western frontier, simultaneously standing firm in the face of an explicit threat from the North. His wisdom, quiet courage, firm determination, sincerity, compassion and simplicity were conspicuous factors in the ability of our nation to come through these difficulties and to set course for further progress. The Tashkent Declaration, the last act of Shastriji's, stands out as a most outstanding example of the manner in which disputes - international or within a nation - should be resolved. Through this lecture, I join the Indian Agricultural Research Institute in paying homage to Shastriji and his immense contributions.

After successive years of serious drought, agricultural production in India during the past two years has staged a remarkable recovery, and in many areas has made what may well be regarded a break-through. Great credit for this must go to the agricultural scientists, the plant breeders, the increased supply of fertilizers,

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* First Lal Bahadur Shastri Memorial Lecture of the Indian Agricultural Research Institute delivered at New Delhi on 7th April 1969.

the sustained agricultural extension work which has been conducted over a period of time and the policy makers who have promoted imaginative programmes. The Indian Agricultural Research Institute has itself played a notable role under the leadership of Dr. Swaminathan. We now talk of a green revolution and look to it to transform our society. It is my purpose today to examine how green indeed is this revolution. Is power an essential ingredient for increasing agricultural productivity? Can the revolution sustain itself unless the Intensive Agricultural Development Programmes at the District level are backed up by equally imaginative action involving the Centre and the States co-operatively? Without an understanding of these matters, the green that we see would be like the green that suddenly appears on the landscape after the first showers in June, only to become brown again when the monsoon is delayed.

In considering these questions, I shall draw on studies conducted by the Indian Atomic Energy Commission related to the implications of an agro-industrial complex based on low cost energy centres. I shall also share some thoughts concerning change itself and the social and political environments in which things are likely to happen. I hope to be excused for using analogies drawn from physical and biological processes. I do so not so much because they are applicable to the situations in each case on a priori considerations, but because each illustrates a useful point.

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Recently, Professor Raj has examined some questions concerning growth, transformation and planning of Agriculture in the Developing Countries. He has in particular, compared experience

*"Some questions concerning Growth, Transformation and Planning of Agriculture in the Developing Countries", by Prof. K.N.Raj, Delhi School of Economics, being published in Vol.I, No. 1 of the Journal of Development Planning, April 1969, Centre for Development Planning of the United Nations.

in Mexico, Taiwan and India (for the period 1952 to 1965). I realise that the study does not cover the past three years during which it is claimed that a qualitative change has occurred in Indian agriculture. Some of the conclusions he draws concerning the limited potential for new technology in non-irrigated lands may therefore require modification. However, the important point he notes is that in only 3 States, namely Punjab, Gujarat and Madras, did the compound rates of agricultural growth exceed by a good margin the rate of population growth. For the best of these, the performance is indeed comparable with the much praised results obtained in Mexico and Taiwan. On the other hand, in three of our most populous States, namely Uttar Pradesh, West Bengal and Kerala, we have a situation wherein the population growth rate exceeds the rate of agricultural output. Raj concludes, and I quote:

> "New varieties yielded more only with substantial complementary inputs of chemical fertilizers and other plant nutrients, and they in turn required assured supplies of water at specified intervals. Without such supplies there was danger of not only the complementary inputs becoming infructuous but, in some cases, of the yield being lower than from the use of the older varieties without applying these inputs.
>
> The percentage area of the land that can be provided with assured supplies of water imposes therefore a limit to the rates of growth that can be realised by technological change".

Almost two years ago, the Atomic Energy Commission of India initiated a study to explore the implications of abundant low cost power to agriculture. It had the benefit of a similar study conducted by the Oak Ridge National Laboratory of the U. S. Atomic Energy Commission.

A number of major electricity consuming outlets such as electro-chemical and electro-thermic processes and pumping of underground water through tube wells have been examined in addition to desalination of water. This is to ascertain whether by a careful choice of energy consuming projects related to a low cost energy producing centre, one could provide not only fresh inputs for economic development, but a balanced load within the grid system.

In areas where underground water is available in plenty like in the Western Indo-Gangetic region of Uttar Pradesh, the use of low cost electrical energy for lifting water along with modern agricultural methods can make a crucial difference to the profitability of farming and will have a great impact on the economy of the country.

The detailed implications of the Agro-Industrial-Complex have been evaluated for a region of Western Uttar Pradesh. The area covers a population of 23. 6 million people. It has Delhi to the west, Agra to the south and the Ganges flowing through the middle. There is a large amount of underground water and the soil is mostly alluvial in character. A suggested installation involves a power station with two nuclear reactors each of 600 MWe capacity. This is because in this region nuclear power would be more economical than thermal power. A fertilizer plant of total capacity of 4,500 tonnes per day and an aluminium plant of 150 tonnes per day are envisaged with approximately 200 MWe used for lift irrigation through 36,000 tube wells.

The total investments of the project is about Rs. 429 crores. The return on this investment is expected to be about 14%. In arriving at this evaluation, differential tariff rates of 2 p/kwh for fertilizers, 2.6 p/kwh for aluminium and 10 p/kwh for tube wells have been assumed. At this power cost for fertilizers, the project is com-

parable to a similar one based on coal even at a pithead coal price of Rs. 35 to Rs. 40. Though the power cost for the tube wells has been taken high, still the agricultural project gives sufficiently high returns. Approximately 720,000 hectares are proposed to be irrigated under this project. The total incremental cereal production would be 4. 5 million tonnes and in addition 700,000 tonnes of pulses would also be produced. The implementation of the project would result in an increase in the per capita income in the area to the extent of Rs. 150 per annum, or about 20%. The per capita income of persons directly engaged in the project would increase by about Rs. 1400 per annum. The project by itself would contribute Rs.486 crores to the gross national product.

Since only about 50% of the fertilizer production is utilised within the complex, the balance would be available for use outside. The benefits derived from this by way of increased food production, increased GNP, increased per capita income, etc. though quite high, are not included in the above figures. If we assume the same yield rates outside, the additional increase in GNP on crops will be of the order of Rs. 400 crores (@ Rs. 5000/- hectare for 0. 8 million additional hectares).

If the area under the project is considered as a food factory, the surplus food production in the region can be a dependable source for food grain for procurement purposes. In a limited region, the procurement would be easier and can be efficient as compared to the country-wide efforts required today.

A plan of this type can be implemented in phases. While the nuclear power plant of large capacity may take 5 to 6 years to complete, the pumping sets could be energised much earlier through the installation temporarily of smaller conventional power units such as

gas turbines feeding from District centres. These District centres would ultimately be connected with the main grid and the power plants could be moved to new locations. When one considers that the most important tasks faced by India are to increase per capita income and to grow sufficient food for a growing population, it is clear that the establishment of such projects is of great significance.

How is such a plan to be implemented? It requires effort at the national level, since the setting up of atomic power stations is a responsibility of the Central Government. Moreover, a station as large as one generating 1000 MW of electricity, would have to be part of a super grid connecting the important generating points feeding six States. Each State would have to gear its own electricity plan to take up and distribute power to the points at which tube wells would require to be constructed and energised. There would need to be local organisations for digging the tube wells on a cooperative basis and for maintaining them in good working condition. There would be need for hardware -the cables, the distribution towers, switch gear, pumping sets, pipes for the tube wells. Unless everything in this total framework, from the mining of uranium to the production of the nuclear fuel elements and the heavy water, the fabrication of the equipment for the nuclear power stations, its erection and commissioning can be phased with the erection and commissioning of the fertilizer complex and the lift irrigation system, one cannot hope to achieve the results that the system as a whole is capable of providing. It is clear that the operation would involve not only diverse Ministries at the Centre, but divecse departments of State Governments, local governments, Panchayats and Cooperatives, not to speak of the effort that would be required from countless private individuals . Can we name any existing organisation or machinary for undertaking the task? There is nothing in our present sot up which permits us to implement a complex project of this magnitude with complementary inputs to be provided at different levels and by parallel organisations at the same level.

7 Some years ago, there appeared a prize winning essay with the intriguing title "A City is not a Tree, but a semi-lattice".* It was written by Christopher Alexander, a mathematician turned designer. We are not concerned here with cities, nor, for that matter, with trees. But the analysis has a fundamental relevance to social organisations. To those who prefer the clarity of mathematical expression, I will briefly state the proposition in the following way, quoting extensively from the essay. It is useful to consider what a mathematician refers to as "the properties of a set".

A set can be defined as a collection of elements which for some reason we think of as belonging together. When the elements of a set belong together because they cooperate or work together somehow, we call the set of elements a system. In the example of Western Uttar Pradesh, which I have described, the elements of our set would be, for instance, the farmer, the seeds, Dr. Swaminathan, the fertilizer, the industrial chemist, the Chairman of the Panchayat, the operator who maintains a tube well, the District Collector, the Manager of the electricity distribution company etc. All these together form the system which we refer to as the agro-industrial complex.

The semi-lattice axiom goes like this: "A collection of sets forms a semi-lattice if and only if, when two overlapping sets belong to the collection, then the set of elements common to both also belongs to the collection".

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* "A City is not a Tree" - by Christopher Alexander, originally appeared in the American Journal "Architectural Forum", 1966.

The tree axion states: "A collection of sets forms a tree if, and only if, for any two sets that belong to the collection, either one is wholly contained in the other, or else they are wholly disjoint". If our system has the structure of a semi-lattice, we could have all the elements of our set cooperating without having to move from their respective substantive positions. On the other hand, if it has the structure of a tree, we would need to either transfer Dr. Swaminathan to the services of the Agro-Industrial Complex or do without his advice altogether, unless every single element, including the Manager of the Electricity Company, needs to consult him.

Every tree is a trivially simple semi-lattice.

We are concerned with the difference between structures in which no overlap occurs, and those structures in which overlap does occur. It is not merely the overlap which makes the distinction between the two important. Still more important is the fact that the semi-lattice is potentially a much more complex and subtle structure than a tree. We may see just how much more complex a semi-lattice can be than a tree in the following fact: a tree based on 20 elements can contain at most 19 further subsets of the 20, while a semi-lattice based on the same 20 elements can contain more than one million different subsets. Whenever we have a tree structure, it means that within this structure no piece of any unit is ever connected to other units, except through the medium of that unit as a whole. The enormity of this restriction is difficult to grasp. It is a little as though the members of a family were not free to make friends outside the family, except when the family as a whole made a friendship.

It must be emphasised, lest the orderly mind shrink in horror from anything that is not clearly articulated and categorised in tree form, that the ideas of overlap, ambiguity, multiplicity of aspect, and the semi-lattice, are not less orderly than the rigid tree, but more so. They represent a thicker, tougher, more subtle and more complex view of structure.

In a traditional society, if we ask a man to name his best friends and then ask each of these in turn to name their best friends, they will all name each other so that they form a closed group. A village is made of a number of separate closed groups of this kind. But today's social structure is utterly different. If we ask a man to name his friends and then ask them in turn to name their friends, they will all name different people, very likely unknown to the first person; these people would again name others, and so on outwards. There are virtually no closed groups of people in modern society. The reality of today's social structure is thick with overlap - the systems of friends and acquaintances form a semi-lattice, not a tree.

Edward Banfield, in a book called Political Influence, gives a detailed account of the patterns of influence and control that have actually led to decisions in Chicago. He shows that although the lines of administrative and executive control have a formal structure which is a tree, these formal chains of influence and authority are entirely overshadowed by the <u>ad hoc</u> lines of control which arise naturally as each new city problem presents itself. These <u>ad hoc</u> lines depend upon who is interested in the matter, who has what at stake, who has what favours to trade with whom.

This second structure, which is informal, working within the framework of the first, is what really controls public action. It

varies from week to week, even from hour to hour, as one problem replaces another. Nobody's sphere of influence is entirely under the control of any one superior; each person is under different inofaences as the problems change . Although the organisation chart in the mayor's office is a tree, the actual control and exercise of authority is semi-lattice-like.

Development involves many disciplines and many levels of political and administrative decision making. The agricultural development of western Uttar Pradesh would be dependent for its power needs on the northern grid and cooperation between the Centre and the various States which are related to this grid. For fertilizers it would be related to some Central, perhaps some State supported and some private enterprises. It would obviously be impossible to expect that all these operations, of generating power, of producing fertilizers and of distributing electricity should be under one authority. But we do require to mobilise all the functions for a particular task through entrusting the management responsibility to a single administration relating itself separately and at different times with different organisations as need may arise. The T. V. A. project in the United States is an outstanding example of the manner of dealing with the problems of development of a region as a whole, independent of State frontiers. Attempts have been made from time to time in this country to follow the same philosophy. I am of course aware that many of these have run into difficulties and the idea is often viewed with cynicism. But if we wish our green revolution to take root, there is no alternative but to examine our mistakes in the past and continue to develop our skills to make such structures work. After all, with linguistic provinces, we have now to take special steps to ensure that a situation does not arise where responsibility for all aspects of development becomes co-terminus with the boundaries of each State.

Professor Raj has observed, and I quote:-

"Clearly, if the areas in which the technology can be rapidly transformed are limited by inadequate supplies of water, the case for making the most efficient use of resources in the regions in which such transformation is possible (as well as elsewhere) becomes even stronger than otherwise. This is where the need to make institutional changes in agriculture comes in".

"This aspect of the problem has been getting increasingly neglected in recent years in the belief that technological changes in agriculture can by themselves yield high rates of growth and that, since institutional reforms call for strong political action that might meet with resistance, it is wiser to concentrate on the former".

Unless planning, management and organisation are put on a sound basis, there is little hope of our fulfilling expectations aroused by the green revolution. A Physicist studying the properties of matter has to understand what happens when he attempts to produce a deformation or a change by applying force. He knows the difference between elastic deformation and inelastic changes. In the first, as soon as the force is released, the body returns to its original state. But in the second, when the limit of elastic deformation is exceeded, a permanent change is produced, which maintains itself even when the applied force is no longer present. It is important to assess the minimum critical effort required to produce a permanent change, for it is not as if with small effort we can produce a small change. When we have, as in this country, many desirable things to accomplish and large areas to be covered with limited resources, one is apt to regard

that spreading effort widely, even though thinly, is the most sensible thing to do, since it appears to satisfy a social objective, In fact, what we generally do, through such a process, is to stall completely the take off, so that historical and unorganised rather than consciously planned factors determine the unfolding of events.

A physicist learns of hysterisis in magnetism, where the amount of effort required to initiate change is much larger than the effort required to sustain it after the process has commenced. This is a commonly observed phenomenon whenever one is studying a property that arises from the cooperative behaviour of a number of small domains, each of which contributes a little to the total effect. Once the change has set in, the force developed through the internal cooperation of the various elements permits further inputs from outside at a greatly reduced level, even if the process does not become completely self-sustaining, as in a chain reaction where net energy is liberated.

From these two aspects of change taken together, we see clearly the relevance of a selective approach which requires effort in each case on a decisive scale, permitting the direct benefits to be given to different areas only in succession rather than through simultaneous action throughout the country at a level so feeble that the impact is scarcely made.

As Raj has observed: "The availability of modern technology leads very often only to dualism in the agricultural sector (as in Mexico) rather than to transformation of traditional agriculture". In a democratic society, to adopt policies which involve a selective approach is undoubtedly difficult. It should, however, be possible to do so if theeconomically most backward areas are the objects of

discernible and highly preferential treatment by the State. Criteria for selection based on the single minded pursuit of optimisation of growth with a given effort can only increase the gap between the rich and the poor sections of the nation, jeopardising internal security.

There are several items in our every day experience where 1 + 1 is equal to 2. This is when one is dealing with sealer quantities like money, or kilograms of wheat or gallons of water. However, generally in nature things cannot be dealt with like this since indeed their effects are not additive in a simple way. In most cases, the total is not equal to the sum of its parts. This is of course well appreciated by those who directly engage in agriculture, but if one examines the assumptions and conclusions of the Planners, who deal largely with financial resources and expenditure, it is clear that this fact can bear restatement.

The order in which things are put together plays an important role in determining the final properties of an aggregate. This can be observed even in inanimate molecules like the sugars where those with atoms arranged along a right handed screw have different properties from the compounds with a left handed arrangement. This is particularly so in the context of social change where the sequence of events is crucial to the realisation of an end objective. A clear appreciation of this is vital for the management of our green revolution at various levels.

An agriculturist dealing with biological systems knows only too well that unless appropriate inputs are made at appropriate times, growth can be inhibited. The influence of protein deficiency in the development of a new generation, the effects of momentary loss of blood in producing irreversible changes in the neurons in our brain

are dramatic examples of what happens to biological systems. Social systems react similarly. The influence of a stop-go policy in providing support to organisations for development can be equally deliterous.

The establishment of the package programmes for agriculture is itself a recognition of many of these factors. Effort is concentrated in a given area where one is trying to provide all the inputs that are considered necessary. It is recognised that as new practices get accepted, effort from outside can be on a reduced scale and fresh areas taken up. The package programme involves an imaginative and what was at the time an unconventional approach to the problem of increasing food production. The question is: Is it sufficient to carry us forward? What do we have at the State or the national levels as counterparts ?

While physical analogues are useful for understanding some aspects of change, biological analogues which involve dynamic equilibrium provide many insights to social situations. One of the most important aspects to note in this connection is that a biological system lives only as long as it receives and gives to its environment. This mutuality of all living systems with the environment imposes the need for inter-dependent existence - on a micro as well as macro scale -a principle, which could well be kept in mind in our political and social organisations. This indeed was embodied in the Tashkent Declaration by Shastriji following the traditions established by Gandhiji and Jawaharlalji. Can we afford to ignore mutuality now?

HOW GREEN IS OUR REVOLUTION*

by Vikram Sarabhai

I deem *it a* great privilege to be invited to deliver the First Lal Bahadur Shastri Memorial Lecture of the Indian Agricultural Research Institute. Lal Bahadurji was at the helm of affairs at one of the most critical phases in Indian history since Independence. While he was creating a new style of national leadership after the death of Jawaharlalji, his Government had to mobilise the nation to repulse a vicious military invasion on its Western frontier, simultaneously standing firm in the face of an explicit threat from the North. His wisdom, quiet courage, firm determination, sincerity, compassion and simplicity were conspicuous factors in the ability of our nation to come through these difficulties and to set course for further progress. The Tashkent Declaration, the last act of Shastriji's, stands out as a most outstanding example of the manner in which disputes - international or within a nation - should be resolved. Through this lecture, I join the Indian Agricultural Research Institute in paying homage to Shastriji and his immense contributions.

After successive years of serious drought, agricultural production in India during the past two years has staged a remarkable recovery, and in many areas has made what may well be regarded a break-through. Great credit for this must go to the agricultural scientists, the plant breeders, the increased supply of fertilizers,

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* First Lal Bahadur Shastri Memorial Lecture of the Indian Agricultural Research Institute delivered at New Delhi on 7th April 1969.

the sustained agricultural extension work which has been conducted over a period of time and the policy makers who have promoted imaginative programmes. The Indian Agricultural Research Institute has itself played a notable role under the leadership of Dr. Swaminathan. We now talk of a green revolution and look to it to transform our society. It is my purpose today to examine how green indeed is this revolution. Is power an essential ingredient for increasing agricultural productivity? Can the revolution sustain itself unless the Intensive Agricultural Development Programmes at the District level are backed up by equally imaginative action involving the Centre and the States co-operatively? Without an understanding of these matters, the green that we see would be like the green that suddenly appears on the landscape after the first showers in June, only to become brown again when the monsoon is delayed.

In considering these questions, I shall draw on studies conducted by the Indian Atomic Energy Commission related to the implications of an agro-industrial complex based on low cost energy centres. I shall also share some thoughts concerning change itself and the social and political environments in which things are likely to happen. I hope to be excused for using analogies drawn from physical and biological processes. I do so not so much because they are applicable to the situations in each case on a priori considerations, but because each illustrates a useful point.

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Recently, Professor Raj has examined some questions concerning growth, transformation and planning of Agriculture in the Developing Countries He has, in particular, compared experience

*"Some questions concerning Growth, Transformation and Planning of Agriculture in the Developing Countries", by Prof. K. N. Raj, Delhi School of Economics, being published in Vol. I, No. 1 of the Journal of Development Planning, April 1969, Centre for Development Planning of the United Nations.

in Mexico, Taiwan and India (for the period 1952 to 1965). I realise that the study does not cover the past three years during which it is claimed that a qualitative change has occurred in Indian agriculture. Some of the conclusions he draws concerning the limited potential for new technology in non-irrigated lands may therefore require modification. However, the important point he notes is that in only 3 States, namely Punjab, Gujarat and Madras, did the compound rates of agricultural growth exceed by a good margin the rate of population growth. For the best of these, the performance is indeed comparable with the much praised results obtained in Mexico and Taiwan. On the other hand, in three of our most populous States, namely Uttar Pradesh, West Bengal and Kerala, we have a situation wherein the population growth rate exceeds the rate of agricultural output. Raj concludes, and I quote:

> "New varieties yielded more only with substantial complementary inputs of chemical fertilizers and other plant nutrients, and they in turn required assured supplies of water at specified intervals. Without such supplies there was danger of not only the complementary inputs becoming infructuous but, in some cases, of the yield being lower than from the use of the older varieties without applying these inputs.
>
> The percentage area of the land that can be provided with assured supplies of water imposes therefore a limit to the rates of growth that can be realised by technological change".

Almost two years ago, the Atomic Energy Commission of India initiated a study to explore the implications of abundant low cost power to agriculture. It had the benefit of a similar study conducted by the Oak Ridge National Laboratory of the U. S. Atomic Energy Commission.

A number of major electricity consuming outlets such as electro-chemical and electro-thermic processes and pumping of underground water through tube wells have been examined in addition to desalination of water. This is to ascertain whether by a careful choice of energy consuming projects related to a low cost energy producing centre, one could provide not only fresh inputs for economic development, but a balanced load within the grid system.

In areas where underground water is available in plenty like in the Western Indo-Gangetic region of Uttar Pradesh, the use of low cost electrical energy for lifting water along with modern agricultural methods can make a crucial difference to the profitability of farming and will have a great impact on the economy of the country.

The detailed implications of the Agro-Industrial-Complex have been evaluated for a region of Western Uttar Pradesh. The area covers a population of 23. 6 million people. It has Delhi to the west, Agra to the south and the Ganges flowing through the middle. There is a large amount of underground water and the soil is mostly alluvial in character. A suggested installation involves a power station with two nuclear reactors each of 600 MWe capacity. This is because in this region nuclear power would be more economical than thermal power. A fertilizer plant of total capacity of 4, 500 tonnes per day and an aluminium plant of 150 tonnes per day are envisaged with approximately 200 MWe used for lift irrigation through 36,000 tube wells.

The total investments of the project is about Rs. 429 crores. The return on this investment is expected to be about 14%. In arriving at this evaluation, differential tariff rates of 2 p/kwh for fertilizers, 2.6 p/kwh for aluminium and 10 p/kwh for tube wells have been assumed. At this power cost for fertilizers, the project is com-

parable to a similar one based on coal even at a pithead coal price of Rs. 35 to Rs. 40. Though the power cost for the tube wells has been taken high, still the agricultural project gives sufficiently high returns. Approximately 720,000 hectares are proposed to be irrigated under this project. The total incremental cereal production would be 4. 5 million tonnes and in addition 700,000 tonnes of pulses would also be produced. The implementation of the project would result in an increase in the per capita income in the area to the extent of Rs. 150 per annum, or about 20%. The per capita income of persons directly engaged in the project would increase by about Rs. 1400 per annum. The project by itself would contribute Rs. 486 crores to the gross national product.

Since only about 50% of the fertilizer production is utilised within the complex, the balance would be available for use outside. The benefits derived from this by way of increased food production, increased GNP, increased per capita income, etc. though quite high, are not included in the above figures. If we assume the same yield rates outside, the additional increase in GNP on crops will be of the order of Rs. 400 crores (@ Rs, 5000/- hectare for 0. 8 million additional hectares).

If the area under the project is considered as a food factory, the surplus food production in the region can be a dependable source for food grain for procurement purposes. In a limited region, the procurement would be easier and can be efficient as compared to the country-wide efforts required today.

A plan of this type can be implemented in phases. While the nuclear power plant of large capacity may take 5 to 6 years to complete, the pumping sets could be energised much earlier through the installation temporarily of smaller conventional power units such as

gas turbines feeding from District centres. These District centres would ultimately be connected with the main grid and the power plants could be moved to new locations. When one considers that the most important tasks faced by India are to increase per capita income and to grow sufficient food for a growing population, it is clear that the establishment of such projects is of great significance.

How is such a plan to be implemented? It requires effort at the national level, since the setting up of atomic power stations is a responsibility of the Central Government. Moreover, a station as large as one generating 1000 MW of electricity, would have to be part of a super grid connecting the important generating points feeding six States. Each State would have to gear its own electricity plan to take up and distribute power to the points at which tube wells would require to be constructed and energised. There would need to be local organisations for digging the tube wells on a cooperative basis and for maintaining them in good working condition. There would be need for hardware -the cables, the distribution towers, switch gear, pumping sets, pipes for the tube wells. Unless everything in this total framework, from the mining of uranium to the production of the nuclear fuel elements and the heavy water, the fabrication of the equipment for the nuclear power stations, its erection and commissioning can be phased with the erection and commissioning of the fertilizer complex and the lift irrigation system, one cannot hope to achieve the results that the system as a whole is capable of providing. It is clear that the operation would involve not only diverse Ministries at the Centre, but diverse departments of State Governments, local governments, Panchayats and Cooperatives, not to speak of the effort that would be required from countless private individuals. Can we name any existing organisation or machinary for undertaking the task? There is nothing in our present set up which permits us to implement a complex project of this magnitude with complementary inputs to be provided at different levels and by parallel organisations at the same level.

Some years ago, there appeared a prize winning essay with the intriguing title A City is not a Tree, but a semi-lattice".* It was written by Christopher Alexander, a mathematician turned designer. We are not concerned here with cities, nor, for that matter, with trees But the analysis has a fundamental relevance to social organisations. To those who prefer the clarity of mathematical expression, I will briefly state the proposition in the following way, quoting extensively from the essay. It is useful to consider what a mathematician refers to as the properties of a set".

A set can be defined as a collection of elements which for some reason we think of as belonging together. When the elements of a set belong together because they cooperate or work together somehow, we call the set of elements a system. In the example of Western Uttar Pradesh, which I have described, the elements of our set would be, for instance, the farmer, the seeds, Dr. Swaminathan, the fertilizer, the industrial chemist, the Chairman of the Panchayat, the operator who maintains a tube well, the District Collector, the Manager of the electricity distribution company etc. All these together form the system which we refer to as the agro-industrial complex.

The semi-lattice axiom goes like this: "A collection of sets forms a semi-lattice if and only if, when two overlapping sets belong to the collection, then the set of elements common to both also belongs to the collection".

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* "A City is not a Tree" - by Christopher Alexander, originally appeared in the American Journal "Architectural Forum". 1966.

The tree axion states: "A collection of sets forms a tree if, and only if, for any two sets that belong to the collection, either one is wholly contained in the other, or else they are wholly disjoint" If our system has the structure of a semi-lattice, we could have all the elements of our set, cooperating without having to move from their respective substantive positions. On the other hand, if it has the structure of a tree, we would need to either transfer Dr. Swaminathan to the services of the Agro-Industrial Complex or do without his advice altogether, unless every single element, including the Manager of the Electricity Company, needs to consult him.

Every tree is a trivially simple semi-lattice.

We are concerned with the difference between structures in which no overlap occurs, and those structures in which overlap does occur. it is not merely the overlap which makes the distinction between the two important Still more important is the fact that the semi-lattice is potentially a much more complex and subtle structure than a tree. We may see just how much more complex a semi-lattice can be than a tree in the following fact: a tree based on 20 elements can contain at most 19 further subsets of the 20, while a semi-lattice based on the same 20 elements can contain more than one million different subsets. Whenever we have a tree structure, it means that within this structure no piece of any unit is ever connected to other units, except through the medium of that unit as a whole. The enormity of this restriction is difficult to grasp. It is a little as though the members of a family were not free to make friends outside the family, except when the family as a whole made a friendship.

It must be emphasised, lest the orderly mind shrink in horror from anything that is not clearly articulated and categorised in tree form, that the ideas of overlap, ambiguity, multiplicity of aspect, and the semi-lattice, are not less orderly than the rigid tree, but more so. They represent a thicker, tougher, more subtle and more complex view of structure.

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Edward Banfield, in a book called Political Influence, gives a detailed account of the patterns of influence and control that have actually led to decisions in Chicago. He shows that although the lines of administrative and executive control have a formal structure which is a tree, these formal chains of influence and authority are entirely overshadowed by the ad hoc lines of control which arise naturally as each new city problem presents itself. These ad hoc lines depend upon who is interested in the matter, who has what at stake, who has what favours to trade with whom.

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varies from week to week, even from hour to hour, as one problem replaces another. Nobody's sphere of influence is entirely under the control of any one superior; each person is under different inofaences as the problems change . Although the organisation chart in the mayor's office is a tree, the actual control and exercise of authority is semi-lattice-like.

Development involves many disciplines and many levels of political and administrative decision making. The agricultural development of western Uttar Pradesh would be dependent for its power needs on the northern grid and cooperation between the Centre and the various States which are related to this grid. For fertilizers it would be related to some Central, perhaps some State supported and some private enterprises. It would obviously be impossible to expect that all these operations, of generating power, of producing fertilizers and of distributing electricity should be under one authority. But we do require to mobilise all the functions for a particular task through entrusting the management responsibility to a single administration relating itself separately and at different times with different organisations as need may arise. The T.V.A. project in the United States is an outstanding example of the manner of dealing with the problems of development of a region as whole, independent of State frontiers. Attempts have been made from time to time in this country to follow the same philosophy. I am of course aware that many of these have run into difficulties and the idea is often viewed with cynicism. But if we wish our green revolution to take root, there is no alternative but to examine our mistakes in the past and continue to develop our skills to make such structures work. After all, with linguistic provinces, we have now to take special steps to ensure that a situation does not arise where responsibility for all aspects of development becomes co-terminus with the boundaries of each State.

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that spreading effort widely, even though thinly, is the most sensible thing to do, since it appears to satisfy a social objective. In fact, what we generally do, through such a process, is to stall completely the take off, so that historical and unorganised rather than consciously planned factors determine the unfolding of events.

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GANDHI CENTENARY CONFERENCE ON SCISNCS, EDUCATION & NON-VIOLENCE.

14-17 OCTOBER 1969

The Conference on Science, Education and Non-Violence was held in connection with the Gandhi Centenary Celebrations at the Gujarat Vidyapith from 14-17 October 1969. It was held under the sponsorship of Gujarat Vidyapith, University Grants Commission, Council of Scientific and Industrial Research, Atomic Energy Commission and Indian National Commission for UNESCO. Scientists and educationists drawn from India and foreign countries participated in the 3-day meeting.

The participants expressed their earnest concern with the imperative need for scientists in all countries, and of every discipline, ranging from physical and biological to social and behavioural sciences, to pay serious attention to the use to which science and technology are put, and the contribution that science can make for strengthening man's commitment to basic values of life exemplified vividly by Mahatma Gandhi's life and work. Gandhiji above all else emphasised that the search for truth demands freedom from dogma, unswevaring faith in reason, humility, and regard for the opinions of others, however contrary and unpleasant.

Man is now at a stage in his history when his future development, even his survival, depends on the success and speed with which he can succeed in transforming the present violence-ridden world to a non-violent society. The situation

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we find ourselves In today is paradoxical and in some ways pathetic; it has been brought about largely by the development of technology and industrialisation, and by the population explosion, which is its side effect. It would however be a mistake to suppose that nan can meet the challenge facing him now except by acquiring more and deeper knowledge about nature and about himself, better control of his environment and resources. The proper use of science and technology should progressively remove poverty and disparities at the national and international level helping the achievement of social and economic equality and elimination of hatred, violence and wars.

The values of truth, non-violence, Dharma and asteya are deeply imbedded in Indian thought, and are an integral part of the history of the evolution of man. In such history and evolutions, there come moments of mutation and the values as lived and expressed by Gandhiji was one such mutation in human evolution. It was a mutation, because the values which he discovered for himself and lived by, were not revealed truths or given dogmas, but were generalised pragmatic norms arising from his own life and that around him and as validated by experience. It was a nutation because his reconstructed values of truth, non-violence, dharma, humility, love, courage and social compassion and justice were not abstract ideals, but sign-posts that ho built on his march through life, and instruments applied to meet every one of the crying problems, personal, familial, socio-economic and political, as he encountered them in his day and age.

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The conference had an exchange of views on Gandhian Values, and some of these are summarised below.

That is the genius and heritage of Gandhiji. He did not merely proclaim that the poor and the meek shall inherit the earth: ho worked to bring about conditions of social justice and political independence, so that the poor and the meek, the downtrodden and the separated could lift up their heads and demand and fight for their rights. This correlation of the ideal with the actual, of thought with action requires the integral unity of thought, feeling, speech and action. In this context, Means are Ends, just as much as Ends becomes Means.

The view was expressed that as regards causes of violence, as also its role in cultural evolution and history, a distinction can be made between violence within nations and societies, and that between nations, i.e., "internal" and external" violence. Violence within nations was considered "abnormal" and the trend in society was to eliminate it, although economic and other social changes have load and continue to lead from tine to tine to violent revolutionary trans formations; but the aim of all societies is to eliminate individual violence (crime) and intergroup violence, such as racial and religious clashes, from its orderly existence. Violence between nations -war - on the other hand, has been considered according to this view "normal", successes achieved by many nations through such violence have led to its glorification in history, literature

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and art, and made. it a prevailing type *of* national behaviour. It *is* the scientific and technological revolution that now calls for termination of such violence - for an end to war. The development of stockpiles of nuclear weapons and other instruments of mass destruction makes it almost certain that any outbreak of large scale war, or escalation, which in the long run nay be inevitable, of "small" or local wars, would bring about a total collapse of human civilization. No nation can expect political profit from such a war. The situation calls for total and comprehensive disarmament, and some positive, though small, steps have been taken in that direction. Much more remains to be done.

At the sane tine it is important that attention be given also to violence within nations in several parts of the world which unfortunately seems to be increasing. Violence, whether between nations or within them, should be regarded as not only a local problem but one for the whole of the mankind and to find a solution all thoughtful man must make their contribution.

We would like to emphasise the importance of case studies of violence and riots involving serious damage to life and property. These should be undertaken in as many countries as possible, and wherever possible and permissible it would be a distinct advantage if some of the case studies could be organised on an international basis, may be under the auspices of UNESCO. The value of such studies, if properly and competently carried out, would benefit all countries and,

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indeed, all mankind. As has often been the case in science, when serious effort is directed, towards the study of a problem, unexpected discoveries of the greatest value often come to light. The study of violence, nay prove as profitable. We would also urge that universities should study, by all means in their power, the phenomena of violence, both national and international, and should endeavour to determine how science could contribute towards reduction and eventual eradication of such acts.

The Conference noted that though the realisation of non-violent society has been the. dream of men at all times, it is only now that it seems possible to realise this goal. Violence in the past was attributable to competition for scarce natural resources which formed the only basis of wealth. Science and technology are now reaching a stage where to meet man's needs it is no longer necessary to compete for such natural resources. "Each country, through intelligent and diligent use of science and technology, can provide a reasonable standard of living for its people. This of course implies not isolation of a country, but a new kind of mutual interdependence in which each country contributes to the progress and welfare of others, without affecting its own interest adversely. In contrast to "natural wealth", which calls for competition in its control, nan-made wealth is potentially unlimited, and therefore could be non-competitive in this sense. This new phase in human cooperation has become possible because of progress in science and technology.

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A first and essential stop in this direction is ensuring free flow of knowledge and technology, of experience and know-how between countries.

The Conference noted that Gandhiji's Non-violence is not a mere abstention from violence. It includes also the positive qualities of humility, compassion, and practical help in overcoming the conditions leading to violence.

A view was expressed that a fundamental condition for a non-violent society is population control. Here also science education can render most valuable assistance. The pursuit of science has been one of the strongest influences liberating the human mind from dogma and superstition. But the use of science and especially technology has so far been primarily for sectional and national ends, and. not for the common interest of mankind. The time has now arrived when science must either serve the interest of mankind as a whole -or the misuse of science will release violence on a large scale -which could lead to an evolutionary failure of the human species and finally to its extinction. The progress of science over the last 2000 years, from modest beginnings through the work of a few in many lands, including India, to its present stage of development, makes it essential that it become a rational ally of the spiritual forces calling for an end of all violence among men. The future of the world lies in a creative partnership between science and Gandhiji's spirit of nonviolence.

A row practical proposals for bringing this climate of opinion into being were put forward. One suggestion was that the prevailing almost universal revolt of youth was a symptom of the desire for such change. Youth is most likely to question basic concepts of present social organisations, including war, and provide the necessary dynamic approach to change. The most far-reaching and revolutionary advances in science are made by very young men. It is most likely that they could make similar contributions to social change leading to a world free from violence.

The adoption by society of values and behaviour patterns which were exemplified by Gandhiji is crucially dependent on Education. Their adoption is needed in the light of historical and scientific experience, and their relevance to contemporary society, faced with the many critical problems arising from the population explosion and technological innovation, is beyond doubt. This is one area in which action is urgently called for, even though a fundamental change can only be seen progressively over a period of time. The three Gandhian principles of basic education, namely integration of education with the processes of life, with productivity processes and with the community are valid today as they were when first stated. They are intended to ensure that throughout his education, a student is not only a receiver but also a creative, positive element in society. They create self-confidence, and facility to live purposefully with others.

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It was recognised that the need of the moment is to re-interpret the original curriculum and methods of basic education, to suit the contemporary scene. Using science, together with crafts and technology, opens now possibilities to fulfil adequately the role originally assigned to crafts alone.

It was emphasised. that the process of striving for, rather than the communication of "knowledge" should occupy the central place in education.

The importance of science in education lies in an attitude which encourages a pupil to question and to exercise initiative for change. Integrating science teaching, and learning through a phenomenological approach, broadens the impact of education.

The emotional needs of individuals need recognition in education as much as an understanding of the rational, and a central objective of education would lie in bringing about a congruence of belief, action and thought, of ends and means.

The importance of introducing scientific knowledge and activities at the earliest stage for creating attitude and values foming the understanding of non-violence was emphasised. So was the importance of consistency of attitudes in child rearing in the family, in education system, in the relationship between different groups, within a nation, and in international affairs.

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An effective science policy should include not only projects which ensure maximal benefits for the nation as a whole but also for projects which have substantial benefits for backward areas. A Science Policy should not be rigidly applied by the central authority but should be flexibly administered so that a community which is willing to make the effort can develop projects of scientific and technological content for its own benefit.

An effective science policy requires clear political and administrative decision making and commitment to the policy. Efficient performance and effective coordination at various levels is necessary for getting expected returns from the implementation of a policy.

The scientific community of the world has a duty to offer its cooperation to the developing countries in ensuring rapid economic growth, removal of disparities and social progress through the application of Science and Technology.

Science is universal and, therefore, the knowledge gained in Science should be shared by all the countries of the world, especially with the developing countries. That is one way to narrow the economic gap between the developing and the developed countries. Scientific progress is irreversible and it is for the good of the whole world, provided the achievements of Science and Technology are used for constructive purposes only.

The conference strongly feels that the accumulated knowledge of science and technology should be utilised for

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constructive purposes. In this respect the developed countries have an obligation to offer cooperation to the developing countries in utilizing the scientific and technological knowledge. The conference feels strongly that the developing countries should give the utmost attention to the development of science and, technology in their societies.

The call to men everywhere in this consideration of Gandhi and values is the call to a commitment, the commitment of the will of man. This call to the will can be responded to by each person in his own way. That response may be the will to suffer, to courage, to sacrifice or to service. But to all, it is a call to carry forward the evolutionary elaboration and development of values and their application, as appropriate to our educational system, particularly in the building of character; to science in its power to conserve, to construct, to create, to innovate and to preserve; to society in its being directed in a pluralist, decentralised deconcentrated and humanized path; to the unceasing fight against social injustices of all kinds and against the current mad momentum of the arms race; and above all to the agonizing and, exciting development demands of our day, of that disinherited, downtrodden three quarters of our fellow men and women, *OUT* rural masses, the Daridra-narayan, towards whom Gandhiji's insistent and accusing finger beckons.

And so we, the Gandhi Centenary Conference on Science, Education and. Non-violence Meeting in Gujarat Vidyapith, Ahmedabad address on this day October 17, 1969, an appeal to

the government of States, the U.N. and the specialised agencies, the international scientific community and its organisations and all men of goodwill, and particularly the youth of the world to study the report of this conference and take all such action as is within their power to execute the various suggestions and conclusions that we have set forth for the achievement of societies and *a* world of peace, progress and non-violence.

We note the important activities already made in this direction, by international scientific associations, such as ICSO, and by the Pugwash Conferences for Science and World Affairs, which regularly bring together scientists from all parts of the world, Bast and West, North and South, for discussion and action in the areas of arias race and development, and urge increased support for these activities by scientific communities everywhere.

nrr/n69

Gandhi Centenary Conference
on
Science, Education and Non-violence
Gujarat Vidyapith, 14-17 October 1969

THE HUMAN BACKDROP
ASSUMPTIONS, EXPERIENCES AND VALUES.

by Vikram
Sarabhai

It is a privilege for the Atomic Energy Commission to be associated with the Gandhi Centenary Conference on Science, Education and Non-violence and I wish to thank the organisers, particularly Shri Morarji Desai and Shri Ramlal Parikh, for inviting me to speak today. Many of us who had the good fortune of having come in contact with Gandhiji in one form or another are conscious of the deep impact that he made on us. I am not concerned with the question whether Gandhiji was pro or anti science, but I know that he was an experimenter in the truest sense, that he firmly believed in the importance of means in achieving goals, and that he had values and attitudes which are profoundly relevant to the present day world. Gandhiji, like "those who have imbibed the spirit of science, had an unflinching adherence to insights born out of his experience so that even in the social and political context he insisted, as a physicist would do, that if a procedure does not work in theory, it cannot be made to work in practice.

Non-violence was a natural consequence of the constellation of assumptions, experiences and values which Gandhiji

carried. For us, gathered to assess the significance of these, with particular reference to science and education, it is worthwhile to identify them, to evaluate whether they are supported or contradicted by historical and scientific experience and to ponder on the manner in which they could be made a part of the natural backdrop of every person.

Gandhiji's assertion that non-violence provides the best path was clearly dependent on the assumption that there is 'good' in everyone. Certain societies have a philosophical and religious base which accepts divinity in all creation. There is no recognition of hell for the long term punishment of the wicked. The Freudian assertion of love and hate coexisting represents the contemporary interpretation of the same principle. Physicists were locked in bitter controversy over the nature of light - whether it consisted of corpuscles or waves - till they realised that the seemingly contradictory observations were manifestations of the same phenomenon. Just as the principle of the superposition of states provided a framework for comprehending many aspects of natural phenomena, so is an understanding of ambivalence crucial, if we are to have a humanistic positive view of life - to give and receive the trust which is fundamental to action.

A second assumption is the inter-dependence of all things in a system of mutuality where giving and receiving are equally important for the survival of each unit. The physical and biological characteristics of an ecological balance based

on the relationship of living organisms to their environment, as translated by Gandhiji in the social context, meant the bringing together of responsibilities with rights. That this principle is valid in the world of every day affairs has been outstandingly demonstrated in the history of labour relations in Ahmedabad starting with the establishment of the Textile Labour Association under Gandhiji's guidance fiftytwo years ago.

A third experience which a scientist would share with Gandhiji would be in recognising the importance of frames of reference. Gandhiji would constantly try to ensure in a conflict situation that a solution had to be perceived as a right and a reasonable one from the point of view of both the opposing sides. Physicists know that the results of observations are vitally related to how the frame of reference of an observer is moving with respect to the frame of reference of the observed. They also know that laws of nature have to be invariant under transformation from one frame of reference to another.

The importance of process or method is well known to the physical scientist who has to deal with the disturbance of the system produced by his observations and the phenomenon of inelastic change and of hysteresis.

Recognition of ambivalence, of ecological balance involving a constant interaction with the environment, of mutuality and the importance of the process as well as of

frames of reference of the observed and the observer are some of the principal assumptions/experiences which form the back-drop of Gandhiji and which contemporary science has also demonstrated as elements of the back-drop of the physical world. Do we however find a recognition of these in individual or social behaviour, nationally or internationally? Is it surprising that societies the world over, industrially advanced and developing; Asian, European, African or American, are experiencing crises of one form or another? The problem is of course aggravated because of the exponential rise of population and the ease of communications and transportation which have produced *a* qualitative change in the nature of human interactions.

With regard to education whose central purpose must surely be to equip each individual with an understanding of the back-drop in relation to which he performs during his life time, we realise that every nation in the world is a developing nation. Educational systems have largely bypassed the need of providing live experiences through which the assumptions, experiences and values which we have talked about, become second nature and an inherent part of the individual. I regard this as a most challenging task facing scientists, because through their enquiry and analysis, they have re-affirmed the validity of these basic concepts which have, in traditional societies, been accepted as flowing from religious faith. The freedoms that science has conferred on man and society have attached constraints which have to be understood.

Knowledge born out of personal experience has to substitute inhibitions or adherence to authoritarian order or fear of consequences hereafter. Moreover, scientists who have relied on the experimental method and the powerful tool of observation, have a particularly valuable contribution to make in providing education through the acquisition of insights by experience rather than by hearing or reading.

I would regard the primary task of education upto the age of 6 or $ to confront the child with experiences and situations in which it will begin to recognise the basic validity of the assumptions and values which we have talked about. This is not the time to discuss in detail the methodology of education that suggests itself, but there is truly a vast scope for innovation and experimentation to be undertaken urgently. Gandhiji himself laid great emphasis on what he termed the technique of basic education. Twenty years after he died we hardly hear of the experiment. Even though I do not have a deep acquaintance of the philosophy and methods adopted in basic education, I am struck by the great relevance of the emphasis on education through experience in every day life. I moreover believe that we do not need expensive equipment and facilities to understand the backdrop and that life as well as nature surrounding us provide a living laboratory in which a child can be provided the insights which we talk about. I know that the Gujarat Vidyapith is working with schools based on principles of basic education in tribal areas of Gujarat.

In the Community Science Centre which has been established in Ahmedabad under the aegis of the Nehru Foundation for Development we have a live interest in this field, and I am hoping that collaboration between the two would give new insights and purposeful direction to this most basic of educational problems confronting society today.

Is Gandhiji dead or alive? No matter what the cynics in our midst may say, Gandhiji does not die because what he represents rests on a basic reality of our physical and social environment. Through efforts such as the present conference and innovative action in education aimed at the acquisition of insights related to our environment we can make more credible the assertion that Gandhiji still lives.

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TELEVISION FOR DEVELOPMENT

by

Vikram Sarabhai Chairman,

Atomic Energy Commission

Presented at the Society for International Development Conference,

Delhi, November 14-17, 1969

TELEVISION FOR DEVELOPMENT

by Vikram Sarabhai

Chairman, Atomic Energy Commission

(Presented at the Society for International Development Conference, Delhi — November 14-17, 1969)

The introduction of television in India has until recently enjoyed low priority. Indeed, in adopting television, India stands almost the lowest amongst the nations of the world, including developing nations. In my view, this is largely attributable to four principal factors. First is the non-recognition of television as one of the most powerful media of mass communication, and therefore of direct relevance to development. Second is the inherently higher unit cost of a T.V. receiver compared to a receiver for sound broadcasting. In consequence, unless community T.V. is organised, it cannot reach the vast majority of our population. Third is the absence of broad-band telecommunication links throughout the country, or even between the major cities. These are necessary to provide national programmes. And fourth is the large dependence, in the past, on importation of equipment and components for broadcasting or reception of television programmes.

The Chanda Committee, which submitted its report on Radio and Television to the Government of India in 1966, recognised the need for an early introduction of television because of the role it can play in social and economic development, and suggested that the plan of the Ministry of Information and Broadcasting which was inadequate in various respects should be replaced by a more ambitious plan.

As a Member of the Bhabha Committee which surveyed in 1964-65 the current status, future potential and scope of governmental initiatives for the development of electronics in India, I was struck by the meagre requirements projected

for television by All India Radio. They had a plan which would start from the very large metropolitan areas of Delhi, Calcutta, Bombay, Madras and Kanpur/ Lucknow and extend to 17 large cities during the Fifth Plan and thereafter progressively to smaller urban areas.

Three years ago, the Department of Atomic Energy, which is responsible for promoting the peaceful uses of outer space, organised a study of the cost and significance of a synchronous satellite to link together isolated rural communities and distant centres of population in India, through a powerful national system for mass communication using television. We felt that there was necessity to gain insights on the manner in which television can be used as a direct instrument for promoting the developmental tasks of Government, so that it can be regarded as an investment rather than an overhead. The Krishi Darshan Programme was organised in 1967 in collaboration with All India Radio, Indian Agricultural Research Institute and the Delhi Administration through the establishment of community television receiving sets in 80 villages around Delhi. Parallel with this, a comparsion of the cost of deploying four alternative systems for providing television on a national scale was made. The following four systems were studied and we had the benefit of experience shared by the National Aeronautics and Space Administration of U.S.A. and participation of specialists from may Indian establishments and Departments of Government.

1. Conventional rebroadcast stations with terrestrial microwave inter connections.
2. Direct broadcast from a synchronous satellite.
3. Conventional rebroadcast stations with satellite interconnections.
4. A hybrid system involving direct broadcast to some areas and five rebroadcast stations for the densely populated regions.

The study carried out quantitatively was based on best current estimates. It indicates that alternative (4) would be one-third as expensive as alternative (1). Ineed all the half million villages of India can be provided television through community viewing centres and a national hookup for a total cost of about Rs. 160 crores under alternative (4). There may be some arguments concerning the precise saving through the use of a synchronous satellite, but every one is agreed

that the saving would be very sizable and indeed the Indian estimates merely confirm the experience in other parts of the world whenever broad-band telecommunications have to be provided over an extended region. If we can allocate each year during the Fifth Plan a sum of Rs. 30 crores for this project, we could cover the entire country by the end of 1979 using a synchronous satellite. With the same annual expenditure of funds relying on existing technologies, it would take up to 1990 to achieve the same coverage.

A national programme which would provide television to about 80 per cent of India's population during the next 10 years would be of great significance to national integration, for implementing schemes of economic and social development and for the stimulation and promotion of the electronics industry. It is of particular relevance to the large population living in isolated communities.

For undertaking a programme to provide television nationally on the scale indicated, it would be necessary to rely largely on Indian expertise and indigenous supply of hardware. To use it effectively as a means of promoting national integration and development, experience requires to be gained on the side of content and programming, in applications to education, agricultural extension, promotion of family planning and national integration. Moveorver, insights in managerial and technical questions related to the operation and maintenance of television sets in rural areas, often with no established electric supply, would need to be gained.

Phase 1 from 1969 to 1973 would prepare the foundation for implementing the programme largely on an Indian base involving design, development and fabrication of equipment, establishment of management systems as well as software skills in each subject area. During this phase, practical experience would be gained through the DAE-NASA ITV Experiment, which is described in an attached background paper.

Phase 2 from 1974 to 1979 would involve progressive coverage through 100,000 or 150,000 new community reception centres each year.

Taking into consideration the cost of installing a television receiver and the purchasing power of the people, it is felt that the stated objectives will largely

involve provision of television through community sets rather than through privately owned sets. It is estimated that not more than 1 to 2% of the total population would be viewing through privately owned sets. The balance of 98% can only be reached through community receivers. Therefore, unlike the field of radio, where individual listening has now become increasingly popular and accounts for the vast majority of coverage, the situation in teleivison would be qualitatively different and would involve the State or public bodies, organisations and institutions providing community viewing facilities. Indeed, the bulk of the cost of the project arises from this item.

II. Recent Technological Developments

The advent of synchronous communication satellites has a special relevance to developing nations which have not still acquired an extensive infra-structure of tele-communications with older technologies. Even though an optimum system in the future is expected to have ground tele-communications as well as satellite tele-communications, there are unique opportunities for optimising a system in respect of its cost and effectiveness where the existing investment is relatively small. India can profit from this situation provided it can use satellite communications for its national needs meaningfully and with imagination. The UNESCO Study Group on Satellite Instructional Television has endorsed the unique contribution which this new technology can make to developing nations and identified India as a particularly appropriate area for early implementation.

With increase of launching capabilities permitting satellites of heavier weight to be put into synchronous orbit, the power available in the satellite for the active reflection to the earth of radio transmissions has increased enormously. With increase in power, the size and sophistication of the ground station can be greatly reduced.

With the development of satellite technology, it is now possible to put a reflector on the satellite which will direct the radiated beam to a narrow region, thus economising on power as well as providing effective service in a desired area of limited extent. This is particularly important for reception of television signals. It is now possible to consider, as in the DAE-NASA experiment a system in which an augmented television set with a small chicken mesh antenna will

itself be able to receive directly from a satellite, television programmes on a national or regional hook up.

A third major break-through has been in the reliability and effective life of operation of satellites. Current experience indicates that a satellite can provide dependable service for at least five years and could have an effective life time exceeding seven years.

HI. Mass media for developmental tasks

In any developing country, one of the prime ingredients of development is the dissemination of information: information about new fertilizers, seeds, insecticides, cropping patterns, new technology, new findings and discoveries in all fields, new goods and services, new living patterns, etc. The process of education is basically related to an information dissemination/transfer process. For the rapid and sustained growth of developing countries, the urgent need to disseminate information to the masses is obvious.

Mass media are clearly the main component in this system of information transfer. Newspapers, movies, radio and television are the primary mass media. In India, we have a very large film industry — one of the biggest in the world. However, movie theatres are concentrated mostly in the larger towns and cities. Though there are some "travelling cinemas" which go around smaller towns and villages, these are few and a very small percentage of the total population is actually reached by them. Just over 4000 cinema theatres with a seating capacity of under 3 million are obviously inadequate for a population of over 500 million.

With the availability of inexpensive transistorised ralio sets costing less than Rs. 100/-, the radio is becoming the medium with the largest coverage amongst the masses. The battery operated transistorised set has also permitted it to reach the population living in large number of unelectrified villages.

Television is ideal as a medium to convey information and news to the broad masses of people — particularly to the illiterate segment of the population, on whom such an audio visual medium would have a profound impact.

The following questions immediately arise in developing a television system for India.

(a) Should one concentrate on providing the benefits first to urban communities and progressively go to rural areas? Direct broadcast of TV from a satellite represents the use of an advanced technology which for the first time does not impose a penalty on account of the dispersal of the receiving units away urban centres. The Indian economy in the next two or three decades must lean heavily on the development of rural areas. It therefore seems to me urgently necessary to take effective steps to enrich life in the isolated rural communities. Moreover, for continued stability and national integration, following the division of the country into linguistic administrative units, there is need to bring together different units through a common mass medium of communication reaching all sections of the population, the young and the old, men and women, the literate and the illiterate, the privileged and the underprivileged. 1 would submit therefore that the answer to this question can be clearly stated. It is that we should consciously reach the most difficult and least developed areas of the country and, because they are in this state, we should reach them in a hurry.

(b) In a state of economic and social backwardness, do we need to deploy imaginatvely the most powerful techniques at our disposal or can we get by with less effective means? In concrete terms, can radio be an alternative to television? I suggest that television has a unique contri bution to make because it has a rare credibility and is most persuasive.

(c) Can we regard T.V. largely as an instrument for development, an invest ment rather than an overhead of society? The answer to this question depends clearly on how we use the medium and who uses it. 1 cannot help nothing that much depends on the objectives and the assumptions of those who create the operating system. This is because the living culture of the system is determined by the people who are associated with it. I have no quarrel with those who wish to provide entertainment through media of mass communication, for society certainly needs enter tainment. But I cannot see the same people determining policies and programming content related to education or instruction through the same medium.

(d) Recognising that Government has a number of different agencies responsible for individual fields such as information and broadcasting, education, agriculture, health, family planning, etc., how can one provide effective management of the system as a whole, alongwith use by the respective agencies of this powerful medium as an integral part of their promotional efforts? 1 would suggest that it should be possible for the other agencies to buy television time for programmes related to the dis charge of their own responsibilities.

(e) Since Government has a very powerful role in promoting development, how can one prevent bureaucratisation of the system of mass communi cations with television? What would be the organisational framework in which programming initative can be developed competitively amongst independent groups of innovative and imaginative producers and artistes instead of through a monopolistic system where just a few official units produce all the programmes that are required? 1 would suggest the creation of a national authority, such as INTELSAT in the international scene, which merely owns, regulates and manages the mass communica tion system without itself taking total responsibility for software. More over, we should promote the development of agencies on a basis of redundancy to competitively provide software for individual clients who would buy time on the television system for promoting national objectives which fall within subjects allocated to them. One would have to provide a feed back system and an evaluation system to assist software develop ment for developmental purposes.

It is quite clear that the problems of management and of software for television system to perform the role of an initiator of change and development are more formidable than the problem of hardware development. But when we have worked through our problems and learnt through experience, we would have gained something far more precious from the standpoint of development than the television system.

DAE-NASA SATELLITE ITV EXPERIMENT

Background paper to

"TELEVISION FOR DEVELOPMENT"

by Vikram

Sarabhai

Chairman, Atomic Energy Commission

The Department of Atomic Energy and the National Aeronautics and Space Administration of U.S.A. signed a Memorandum of Understanding on September 18, 1969 to conduct jointly an instructional television experiment using the ATS-F satellite. This satellite is planned to be launched during the second quarter of 1972. After an anticipated six months of space craft check out and other experimental efforts over the U.S.. the space craft will be moved to a suitable position (20° E longitude or so), at which location it will be made available for the conduct of the experiment.

According to the Memorandum of Understanding, the scientific responsibilities of the Indian Government are :

First, to develop, provide and maintain in service the ground segment of the T.V. satellite experiment that will carry out the technical objectives of the experiment; and

Second, to develop and utilise ITV programme materials that will carry out the instructional objectives of the experiment.

The DAE-NASA experimental satellite T.V. project envisages the provision of 2,000 augmented type of T.V. receivers for direct reception from a synchronous satellite. The 2,000 receivers are proposed to be located in rural areas in clusters of about 500 each. The exact location of the clusters is to be chosen so as to get

the widest possible range of meaningful experience from this experiment. The experiment will lay emphasis on community viewing and on instructional T.V. as an aid to development in the fields of education, family planning, agriculture, social education, etc.

This programme has now been integrated with the programme of All India Radio for the introduction of TV during the Fourth Plan which involves augmenting the capability of the transmitter at Delhi and the establishment of new transmitters at Srinagar, Bombay and Poona and later on in Madras and Calcutta.

The DAE-NASA experiment is related to the following specific Indian instructional and technical objectives :

1. Indian Instructional Objectives Primary

— Contribute to family planning objectives.

— Contribute to teacher training.

— Improve other occupational skills.

— Improve health and hygiene.

2. Indian Technical Objectives

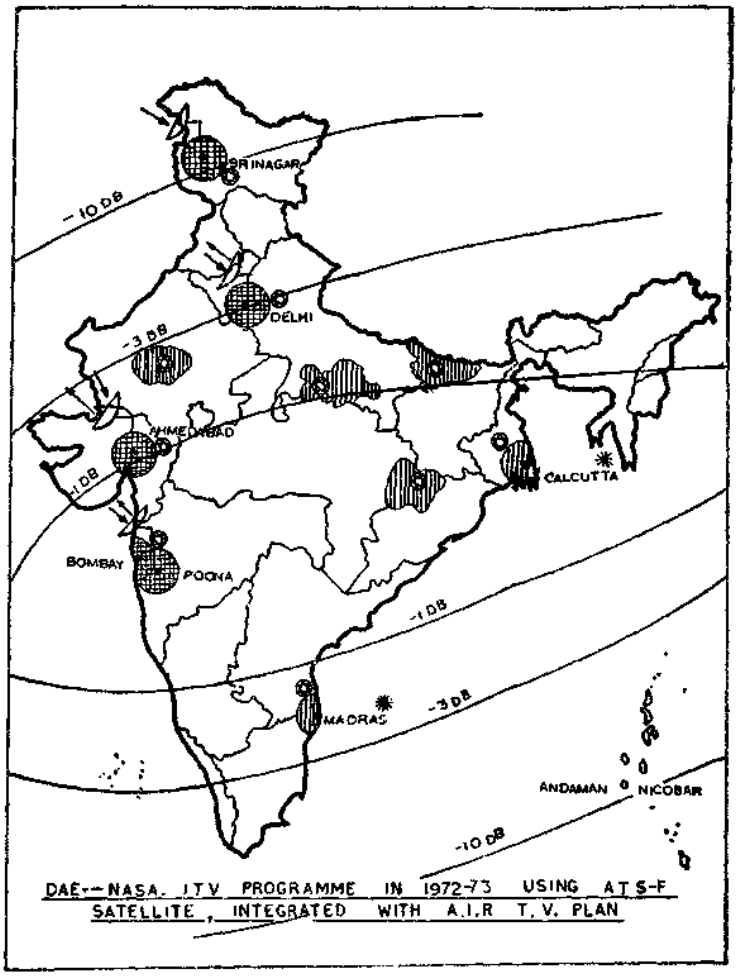
— Provide a system test of broadcast satellite TV for national develop ment.

— Enhance capability in the design, manufacture, development, installation, operation, movement and maintenance of village TV receivers.

— Gain experience in the design, manufacture, installation, operation and maintenance of broadcast and/or distribution facilities to the extent that these are used in the experiment.

— Gain an opportunity to determine optimum receiver density, distribution, and scheduling techniques of audience attraction, and organisation and to solve problems involved in developing, preparing, presenting and trans mitting TV programme materials.

Figure I gives the profile of the coverage that will be attempted in 1972-73. It will be noted that the experiment will permit a national hook-up through a hybrid system involving both direct broadcast and rebroadcast of television signals from ground stations. Since direct broadcast would be more advantageous in isolated communities where the receiver density is low and the scope for development greatest, we have identified our clusters based on the lowest level of development as described in Annexure 1.



Clusters using Rediffusion TV at V.H.F.

Receive only Satellite Earth Terminal

Clusters using Direct Broadcast TV at 850 MHz with about 500 Community Receivers each

Programming Centers

Transmit — Receive Satellite Earth Terminal

To be converted to Rediffusion TV

Figure 1

Annexure 1 to background paper on "Television for Development"

by **Vikram**

Sarabhai

In January 1965, the Planning Commission requested the State Governments to identify backward areas on the basis of a few indicators of development.

We can rank the following States in the order of lowest level of development.

1. Orissa.
2. Bihar
3. Madhya Pradesh
4. Uttar Pradesh
5. Rajasthan
6. Andhra Pradesh
7. West Bengal
8. Mysore.

Selection of Clusters

Orissa & Madhya Pradesh — Cluster No. 1

The Raipur district of Madhya Pradesh and Sambalpur district of Orissa are contiguous. These may, therefore, form a single cluster. The T.V. receivers could be spread out in the bottom level districts of Bustar Korapur, Raigarh, Bilaspur, Kalahandi, Bolangir and Baudh Khandmals. The headquarters of this cluster could be at Raigarh which besides being contiguous to the package programme districts of Raipur and Sambalpur is itself a bottom level dstrict. AIR has broadcasting stations at Raipur and Sambalpur.

Bihar — Cluster No. 2

While Shahbad is a package programme area, Muzzafarpur is the intensive family planning district. Since Muzzafarpur is surrounded by Dharbhanga, Champaran and Saran which are all bottom level districts of Bihar, these may constitute the cluster No. 2. "I he headquarters of this cluster could, if necessary, be at Patna which has an air strip. AIR has a broadcasting station in Patna where an agricultural university is also planned.

Uttar Pradesh — Cluster No. 3

Aligarh in Uttar Pradesh is a package programme area while Kanpur and Allahabad are the intensive family planning districts. Aligarh and surrounding areas are at higher level of development while Kanpur is partly surrounded by bottom level districts. Allahabad on the other hand is surrounded by bottom level districts of Banda, Fatehpur, Rai Bareli. Pratapgarh, and Jaunpur. Cluster No. 3 may, therefore, be spread over these districts with its headquarters at Allahabad, where AIR has a broadcasting station. Allahabad has an agricultural college at Naini and is also accessiable by air.

Rajasthan — Cluster No. 4

While the district of Pali is the pacake programme centre. Udaipur which is the seat of an agricultural university is also intensive family planning district. Pali is surrounded by bottom level districts of Bhilwara, Nagaur and Banner. Pali itself is a second level district.. Cluster No. 4 may. therefore, be spread over these three districts with headquarter either at Ajmer where AIR has a transmitting station or at Pali itself.

CONTROL AND MANAGEMENT OF PUBLIC SECTOR UNDERTAKINGS

by

Vikram Sarabhai Chairman,

Atomic Energy Commission

I. CONTROL

1.1 The primary tasks and constraints*

A clear definition of the primary task of a public sector enterprise serves two important purposes. First, it enables a better understanding of what the organisation is trying to "achieve" or "become" and how appropriate policies within the framework of these objectives may be evolved. Second, it provides a meaningful frame of reference within which to analyse and assess the organisation's performance.

There are three basic objectives which every public sector undertaking in India must attempt to fulfil:

1. To be a leader in providing an "adequate" supply of desired goods and/or services of the right quality that contribute directly or indirectly to the well-being of the nation;

2. To produce and distribute these goods and services with the minimal use of scarce national resources; and

3. To make these goods available to the public at "reasonable prices".

Enterprises can perform many tasks at the same time. Again, the number and distribution of tasks vary between and with enterprises and over time. At any given time, however, each whole or part of any enterprise has a clearly definable primary task - the task that it must perform to survive. Thus, all industrial enterprises must make profits; public utilities must provide servis In making profits, industrial enterprises may provide services,

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*A very valuable analysis furnished by A.K. Rice in "The Enterpris and its Environment" is reproduced as background note 1 .

and in providing services, a public utility may make profits; what is important here is that the primary tasks are different and must be recognised as such. It is this primary task that is referred to in the first objective, of providing the desired goods and services of the right quality. The essential "pace setting" character of a well-run public enterprise is also highlighted. The other two objectives are valid equally in fully competitive as also monopolistic situations.

The people who talk of the public sector having to serve "wider" interests are often confusing objectives with constraints which exist in the Indian situation and which must be taken into account while framing policies and attempting to meet stated objectives.

I would classify constraints into two broad categories. The first category consists of what may be called "general welfare" constraints, which follow from certain national policies adopted by Government. For example, under present Indian conditions, employment and labour welfare are matters of special importance, and the public sector is often exhorted to act as a model employer. Instead of classifying this as an objective, however, it would be more logical to treat the "model employer" concern as a constraint on the public sector flowing from Government's wider policies. The cost *of* this constraint can limit the ability of an enterprise to meet its objectives. For instance, the attempt to provide, amenities for labour beyond what is normally given by industry or beyond what is required to sustain reasonable levels of efficiency must result in a higher cost per unit of output. In this sense, a direct conflict exists between the second objective and the constraint relating to welfare. One can think of other constraints of this type which might prevent the public sector undertakings from fully achieving their objectives, such as political decisions which lead to uneconomic locations and salary structures that make it difficult to attract the most suitable personnel for the jobs at hand. In regard to this category, must also be included certain constraints which are imagined to exist because of an incorrect understanding of the primary task and objectives of an enterprise. For example, the management of an enterprise may decide against automation on the ground that this would result in some retrenchment, which the government would never permit. A little thinking will show that the decision regarding automation which must be taken, if it will improve the functioning of the enterprise, is here being confused with a constraint that Government may (may not) impose that there should be no retrenchment under any circumstances.

The second broad types of constraints are those imposed by Government in the belief that they are essential for the proper

running of an enterprise and may therefore be termed "owners" constraints, since they are of the type that shareholders may impose on a company. An example of this type is the requirement of propriety audit by the Comptroller and Auditor General. It will be explained later how this constraint does not really serve the purpose of better control and is thus self-defeating; to the extent that such constraints exist, they must be recognised as such and taken into account.

All constraints have this common characteristic that they tend to limit the extent to which the objectives of any enterprise can be fully attained. The policies of public enterprises must therefore be so designed as to maximise the achievement of objectives, given the constraints which are beyond the control of the enterprise. Putting this differently, one can say that the enterprises must maximise "profits" within the limits set by the constraints, if the term "making of profit", is used to refer in a brief way to the economic task of ensuring the long term financial stability of an enterprise. In the case of industrial enterprise, this could mean profits in the sense in which the term is normally understood, while for a public utility, it could mean the supply of services at least cost. In particular, it must be emphasised that the term maximisation of profits is not here intended to mean short term maximisation of profits at the expense of future investments, developments or economic stability.

1.2 Ownership and Management - The Holding Company:

Many studies have been undertaken to understand the implications of the non-differentiation of ownership and management in family owned businesses. It has been noted that often the objectives of the family get inextricably mixed up with the objectives of the business. Moreover, sibling rivalries and problems of relationships between members of the family are projected on to the business so that battles within the family are, in fact, fought within the business. In the case of State ownership of business, difficulties of an equally serious type result when the wide objectives of the State are carried over as objectives of public sector enterprises and the rivalries of political parties and groups within the nation are projected within the enterprises. This arises in many ways. I have heard executives of public sector enterprises sincerely expressing the opinion that their enterprises have to serve a wider national interest, apart from the stated objective of economically producing goods or services of the required quality and in required quantities. The economic parameters by which one is to judge in a normal situation the successful performance of this role are then relegated to a secondary place and in some way sought to be off-set against intangible other gains. The struggles of political parties often show
up as industrial disputes.

It is now generally recognised that while there are numerous examples of a family owned and managed business which has successfully taken an enterprise through its initial stages of growth under the dominant control of a family father figure, professional management has almost inevitably taken an important role after the second or third generations. In this second phase, the Board of Directors appointed by the owners who play mainly a shareholders' role constitutes a buffer between the ownership function and the function of management. In the case of a public sector enterprise, experience has shown that the formation by the State of holding companies to act as insulators between the Government with its wider interests and the enterprise with its narrower specific objectives has often proved very valuable.

Most striking examples in this regard can be seen in Italy, where the ENTE NAZIONALE IDROCARBURI (E.N.I.) performs the role of a holding company, providing entrepreneurship as well as broad control at the strategic decision making level for a vast number of enterprises.

A characteristic feature worth noting about a holding company is that the individual operating companies form separate entities. This is therefore to be distinguished from the concept of a sector corporation as proposed by the Administrative Reforms Commission -but happily not agreed to by Government - where a company such as Hindustan Steel would have several individual plants of large size working within it, but not as independent and competing corporate entities.

The separation of ownership from management cannot be done only through institutional means, but requires behavioural norms. In a private company, individual shareholders normally meet annually and exercise their overall control through the passing of accounts, the appointment of Directors and the appointment of Auditors. The Directors meet at least once a quarter, but they do not normally have contacts with the shareholders during the year. In the case of the Public Sector Enterprise, there are two levels which are involved on behalf of the owner. One is the Ministry and the other is Parliament through the Parliamentary Committee on Public Enterprises and through its inherent right of questioning and investigating into the affairs of individual enterprises. While in law, and in fact, the owners of an enterprise have ultimate authority in respect of all aspects affecting the enterprise, the management of the enterprise cannot be carried on effectively without self-discipline, which would desist from using the authority except on very special occasions involved in crisis situations. This self-discipline is reflected normally

through delegation within an appropriate time span of reporting, such that the necessary flexibility that is required in tactical decision making in the interests of the enterprise is not impaired. Here the record is quite patchy, both with regard to the nature of control exercised by the Ministries and the nature of Parliamentary supervision and control. We shall discuss separately the role of audit in management, but clearly in the present context we have also to take note of the role of the Comptroller and Auditor General, who, on behalf of the owners of the enterprise, performs not only a financial audit, but also a propriety audit unlike what obtains in a private business organisation.

1.3 Strategic and Tactical Decision Making - Time Span of delegation and control.

Those who have studied the subject of control systems are aware that a system can only be adequately controlled when the time period of receiving information and responding to it is short compared to the time period in which the event itself is occurring. It might be useful to illustrate this with an analogy. If an aeroplane takes off from Bombay airport, bound for Cairo, and the journey takes five hours, the news of the weather at Cairo airport relevant to the plane making the journey must be available to the pilot in a time shorter than the five hours which he takes for the journey itself. When we apply this to the type of control which Parliament or the Auditor General can perform, we realise that these can affect only decisions and factors related to the progress of business over several years. They can have no relevance to the large number of tactical decisions which are required to be made for the business on a day to day basis and which indeed make all the difference between the success or the failure of the enterprise. If in the exercise of its control functions, a superior body, such as Parliament (or the Comptroller and Auditor General) or the Ministry, concern themselves with tactical decisions, the exercise, apart from not having any significant effect in controlling the situation, can at best inhibit the exercise of initiative in respect of tactical decision making by management. The moral of the story then is that while the bodies supervising a corporation cannot abdicate their right of control, they should exercise it only in respect of those items and decisions which affect the long term future of the enterprise.

We have talked earlier of the merit of an institutionalised buffer between Government and Parliament on the one hand and the individual enterprise on the other. Apart from providing this separation, the merit of a holding corporation can arise from having on its own Board of Directors individuals with administrative, technological and managerial skills, as well as wide experience in finance, industry, marketing and public affairs. Such Board of

Directors could meaningfully translate the objective of Government in promoting an industry in a particular field and secure for it appropriate financial backing as well as management within a subsidiary corporation.

We have discussed here the institutional form and the behavioural aspect of control. Neither of these by themselves are sufficient to ensure success in achieving the primary tasks. However, both together, I would submit, assist in creating conditions under which entrepreneurship as well as sound tactical decisions, with a reasonable amount of risk taking, can be undertaken by the management of the enterprise. The qualification of a person to become a Director of a holding company would be that he understands the management of funds, he can review the financial inputs and outputs of the individual corporations, and he is experienced in the identification of managers for appointment to individual companies promoted by it for specific purposes.

In the exercise of its control functions, Government has felt the need in the past of having specialist groups qualified to study relevant issues and to make recommendations. The Bureau of Public Enterprises is a unit of this type. The Planning Commission Unit on Management is another organisation. The effectiveness of these bodies is dependent on the following factors. First, it is necessary to ensure that in passing down advice to the enterprise, it is not interpreted as a directive tantamount to withdrawing delegation or a control function related to a tactical decision. Second, the advice must originate from those who have demonstrated experience in the particular professional field and not because individual amateur administrators occupy a hierarchical superior position. It is quite clear that greater supervision by staff bodies at the higher levels of control cannot be a substitute for competent management at the level where tactical decision making is made. In other words, the deficiencies of management at the enterprise level cannot be made good by more supervision at a higher level of control.

1.4 Possible Assessment Modes and Mechanisms*

In a report by the U.S. Panel on Technology Assessment*, the implications of internalised and externalised assessment have been well discussed. Implicit in much of this report has been the distinction between internalized assessment - that is, assessment built into the incentive structure of the decision-making process in question - and externalized assessment - that is, assessment

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*Report of the National Academy of Sciences of the USA on Technology - Processes of Assessment and Choice, July 1969.

conducted by an institution deliberately separated from the front-line decision-maker. There has been general agreement in the panel that internalized assessment, whenever it can be applied, is far preferable, essentially because self-regulating ("closed-loop") systems are best able to adjust to net variations within the systems themselves. Externalized assessment, like any form of absentee management, tends to separate authority from responsibility, while internalized assessment tends to redefine responsibility without separating it from authority. However, self-regulating systems may be insensitive to externalities and may have to be supplemented by externalized ("open-loop") assessment. Thus, although there are advantages to being on the scene, proximity and commitment tend to generate blind spots. In sum, any scheme devised for improving the assessment and management of technological change should make maximum possible use of internal decision-making processes and should proceed by making those processes more sensitive rather than by imposing external constraints, but should recognise the necessity for some external assessment and supervision to make the system function properly. Ideally, the effort should be to modify goals and criteria of success without dictating the means of achieving them.

The best point at which the owner of an enterprise, who would be Parliament/Government in the case of the public sector, can perform an overall assessment including propriety assessment is at the level of the Board of Directors where items of policy and strategic decision-making are involved. This is without reference to the performance of financial audit at all levels by an independent outside agency which does not detract from the management functions of the enterprise itself.

1.5 Summarising the subject of control of public sector undertakings, we note the following:-

(a) It is important clearly to define the primary tasks and the constraints within which the organisation operates.

(b) Amongst constraints one needs to distinguish between those related to "general welfare" imposed by the environment and "owner constraints" imposed by the owners who are safeguarding their own rights.

(c) Public sector enterprises in general must maximise profits within the limits set by the "general welfare" constraints. The making of profit is used to refer in a brief way to the economic task of ensuring the long term financial stability and growth of an enterprise.

(d) Some "owner constraints" such as the requirement of the Comptroller and Auditor General to perform propriety audit are self-defeating.

(e) There is merit in providing an institutionalised buffer in the form of a holding company between the owners represented by Parliament/Government and the operating enterprise. This is desirable in view of Government having wider tasks than the more specific primary tasks of an enterprise.

(f) Separation of ownership from management is not achieved through institutional means alone but requires self-discipline on the part of owners expressed through delegation within an appropriate time span. The control of owners must largely be through the review of long range operations and directives affecting strategic decision-making.

(g) Deficiencies of management at the enterprise level are not made good by more supervision at a higher level of control.

(h) Externalised assessment like any form of absentee management tends to separate authority from responsibility while internalised assessment helps to redefine responsibility without separating it from authority.

I am grateful to Professors Kamla Chowdhry, Samuel Paul and V. L. Mote of the Indian Institute of Management, Ahmedabad, for many stimulating discussions and studies on the subject of public sector enterprises and to Shri T.N. Seshan and Shri J. Murli of the Department of Atomic Energy for valuable help.

CONTROL AND MANAGEMENT OF PUBLIC SECTOR UNDERTAKINGS

by

Vikram Sarabhai Chairman,
Atomic Energy Commission

II. MANAGEMENT

In discussing the Management of public sector enterprises, I shall deal with six matters. First, whether financial control should occupy a dominant position within corporate management? Second, the implications of having a chief executive or a committee of management at the top-most level of executive decision making within the corporation. This has relevance to the composition of its Board of Directors. Third, the implications of concurrent propriety audit to executive decision making. Fourth, the importance of "operating culture" rather than the formal organisation structure, in determining how the enterprise, in fact, functions. Fifth, the implications of deputationists to the creation of the "operating culture". This is related to the process of transference of administrative practices and technological know-how. Sixth relates to the problem of motivation, pace setting as well as yard-sticks for performance.

2.1 Management Controls

In analysing the functions of a corporation, we can identify input, conversion and output as forming the main stream of its activities. In a manufacturing concern, for instance, one would regard procurement of raw materials, production and marketing of finished products as the main stream. In order that an enterprise may achieve its primary task, it must regulate the main stream through financial control, quality control and inventory control. What we find, however, in most public sector companies and many private sector corporations as well is that a special role is given to the financial controller, dominating the other managers responsible for functions which control the main stream as well as the other control functions. In the public sector, the origin of this probably lies in traditional concepts of expenditure of public revenues where there is no question of the input, conversion and output of a particular through-put. This biased state of affairs becomes doubly difficult when the financial controller is individually invested with special responsibilities and powers so that a Managing Director is required to consult him and if there is disagreement and he

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over-rules the controller, the point has to be referred for information to the Board of Directors.

One can understand providing finance a special role where the through-put itself is the handling of money as in a Bank. But in any other type of enterprise, where the through-put is not money, the special emphasis on financial control deflects attention away from the primary task. This handicap becomes clear if one pushes this to the limit of absurdity, namely of a person who preserves his financial resource in tact, spending nothing and completely avoids undertaking the primary task. That this absurdity is not so remote from reality in some cases is borne out by the cartoons of Laxman, which one sees from time to time on the subject. What the current concept of the Financial Controller in public sector corporations achieves is an implicit, but ill defined dual management in which at least one of the managers, namely the Financial Controller, is asked to be responsible for the propriety of the financial decisions, as distinct from decisions on general management which the Managing Director must make.

2.2 Implications of a Management Committee

There are many instances where a committee type of management has successfully managed a large corporation. The typical Board of Management of such a corporation would involve, apart from the Managing Director, the Financial Director, the Production Director, the Purchase Director, the Marketing Director, perhaps a Research Director, and the Personnel Director. The Board would collectively take responsibility for the total management of the unit even though the Directors perform special functional roles. One can trace historical and evolutionary factors under which such a system is likely to work. It would seem to me necessary that the managers share a common commitment to the same enterprise and to an equal degree. Moreover, they should all have worked for some time under the same working culture. It is not difficult under these circumstances to realise the problems that arise when Government is called upon to perform an entrepreneurship role, in which, moreover, the Board of Directors is not able to look to a chief executive for the tasks of general management. But, by far a simpler system is one where there is a chief executive who is individually responsible to a Board of Directors and through them to the owners of the company. Professor Kamla Chowdhry has written a note on "Representational Membership of Boards of Directors of Public Sector Undertakings". This note, which is reproduced as background note 2, discusses some of these problems in greater detail.

Concurrent Propriety Audit

In public sector enterprises, there is today provided a system of concurrent audit, which involves not only financial audit, but also propriety audit. Such a concurrent audit can only he performed on a day to day basis by relatively junior staff, who report to their own supervisors outside the management of the company. The procedure ultimately filters out at the level of the Parliamentary Committee on Public Sector Enterprises to whom the Comptroller and Auditor General reports specific instances of questionable propriety. We have noted earlier that the system has a built in time delay, which can operate successfully only in relation to strategic decisions and cannot affect at all the course of tactical decisions. Moreover, for a large number of public servants, who believe that they cannot afford to have an adverse comment, this leads to the adoption of a "play safe" attitude. They either postpone a decision or try to associate with the decision a large number of other persons so that individual accountability can never be established. In most real life situations, individual judgement based on experience and insights plays a crucial role for success. We would not call the process 'the exercise of judgement' if it was infallible. But if amongst 100 perfectly sound decisions based on judgement, 5 are those where the anticipated result did not in fact occur, then the system as it now works, brings out negative comments on the five without any reference to the 95 successes the person may have to his credit. There appears to me no solution to this difficulty which paralyses initiative unless the Managing Director is fully accountable for all aspects of the company's operations and the role of the outside auditor within the corporation is limited to a check of performance in terms of established procedures and authorisations by duly appointed bodies. In other words, the role of audit should be to prevent cheating or defalcation or of unauthorised exercise of authority in excess of delegated functions. This is, in fact, what a commercial auditor would do. In the case of public sector enterprises, Government may wish to have their own auditors do the same function, but an enlargement of the function to include propriety audit, in my opinion, is one of the most important single factors handicapping the performance of the public sector at the present time.

The interests of the owner can be well looked after in an overall sense at the level of the Board of Directors. Undoubtedly, Government as a sole owner would have representatives, who are primarily responsible for safeguarding the objectives of the owner.

. 4 Operating Culture

Frequently in the course of my lecture I have referred to an operating culture of an organisation. This describes the constellation of assumptions, behavioural patterns and responses of the persons in an organisation. In order to convey the flavour of what I am trying to express here, I enclose a table which is entitled "Organisational and Performance Characteristics of different Management Systems based on a comparative analysis" The table is taken from Likert*. It outlines the characteristics of four management systems representing a gradation from an exploitive - authoritative system at one end, to a participative group at the other. It is interesting to observe that the character of motivational forces, of communication process, of interaction - influence process, -of decision-making process, of goal setting or ordering and of control process have been found to be markedly different in the four systems; and so are the performance characteristics like productivity, excessive absence and turn-over, scrap loss and waste, and quality control and inspection.

In real life situations, we do not find it difficult to recognise that the operating culture of an army regiment is different from the operating culture of a Government servant for the administration of a district, and from the operating culture of a University. Each operating culture has, over a period of time, grown through effort to maximise the possibility of achievement of the different primary tasks - for the army regiment, the task of providing a basis in which an individual would be willing to lay down his life in obeying a command; in the district administration, the primary task of conveying impartiality of administration without fear or favour; in the University, the primary task of providing an environment in which people could grow. I suggest that the operating culture of a public sector enterprise has to promote the primary tasks which we defined earlier, namely, to maximise profit within the limits set by the "general welfare" constraints of the environment. And as we observed earlier, the making of profits is used to refer, in a brief way, to the economic tasks of ensuring long term financial stability and growth of an enterprise. The greatest problem in any entrepreneurship function is to provide the appropriate operating culture and this is created by the attitudes and assumptions of the men in it, rather than formal organisation structures.

2. 5 Implications of Deputationists

The practice of manning public sector enterprises with a large number of deputationists drawn from Government departments

*R. Likert, New Patterns of Management, 1961.

has been rightly frowned upon because, in the context of personnel practices in Government, deputationists can normally spend only a brief period (3 to 5 years) in the same enterprise. Not only does this dilute commitment of the deputationists to the enterprise, but it also prevents the building up of a culture in the enterprise appropriate to its primary task. For example, the pre-occupation in Government accounting with gross and cash budgeting very often clouds the manager's horizon and prevents him from keeping a continuous control on cost of production. Though instructions exist for analysis in brief time span of the profit and loss aspects of its commercial activity, the culture of Government accounting very often creates a situation where a study of accounts is delayed until cost consciousness becomes ineffective.

While deputationists who have spent the best part of their lives in an alien operating culture create difficulties in the new organisation, we must recognise that deputationists or the transfer of men from an appropriate culture is, in fact, the best way of promoting an appropriate operating culture in the new establishment. We have industries in fields such as electronics, pharmaceuticals, computers, aviation, Defence, atomic energy, and space research, where the rate of obsolescence and of innovation is very great. The viability of the industries is heavily dependent on the successful performance of the R & D activity. For the primary task, the refore, deputationists from R & D establishments, not on a short time basis, but for extended periods of time till the tasks are completed, can play a very important positive role. This is indeed how R & D carried out in the atomic energy laboratories is transferred to industrial practice, leading ultimately to goods produced and sold commercially by a public sector enterprise such as the Electronics Corporation of India Limited, which was started in Hyderabad in 1967.

This still leaves a major question un-resolved. This is due to the non-recognition of the role of professional management involving an understanding of systems engineering, operations research, production and inventory planning and other techniques necessary for quantitative decision making. This brings out very clearly the need for periodical training of managers in our enterprises, so that, belonging to an operating culture most appropriate to the entrepreneurship function, they can nevertheless understand the needs of the culture appropriate to the primary task of a profit making organisation.

2.6 <u>Motivation and pace setting</u>

I wish finally to deal with the problem of motivation and pace setting in public sector enterprises. In my opinion, a

horizontal control system is most appropriate to a democratic socialist society and also to the growth of science and technology. Competition provides horizontal controls. Innovative action leads to a divergent situation as I tried to explain in an address delivered last year on "Diverging Human Function". My preference for horizontal control systems in contrast to vertical controls is therefore dependent on what I regard fundamental issues facing us. In any case, dealing particularly with public sector enterprises, I believe that promoting competition is perhaps the best way of creating an environment in which pursuit of the primary task, as we have defined earlier, becomes a necessity for survival, rather than a goal which we merely strive to reach.

2.7 We may summarise the observations on the management of public sector undertakings in the following manner:-

(1) There is need to ensure that financial control is not given a dominating position over the functions related to the main stream of input, conversion and output or the other controls such as quality and inventory.

(2) There are inherent difficulties in Government successfully setting up a public sector enterprise for the first time with a Committee of Management, rather than a Chief Executive at the top of the executive function. It is noted that the role given to the financial controller in many enterprises is often tantamount to creating a structure which operates as a Committee of Management of two, even though one of them is designated as the Managing Director.

(3) Concurrent propriety audit undertaken at all levels of the organisation by an authority independent of the enterprise seriously undermines the capacity of management to make decisions based on judgement.

(4) The operating culture appropriate to an enterprise is largely determined on the one hand by the nature of the primary tasks, and, on the other, by the assumptions and behavioural norms of the people involved.

(5) While deputationists, who migrate from one organisa tion to another on the basis of time spent, cannot

in general have a long term commitment to the enterprise in question, the transfer of men for accomplishment of tasks is one of the best practical ways of transferring technology know-how and an operating culture. It is noted that this, nevertheless, creates certain imbalances in regard to the operating culture most appropriate to the primary task of the enterprise. And hence the need to consciously devise executive training programmes.

(6) Public ownership should not be regarded as inconsistent with competition. The presence of competition would stimulate the performance of the public sector.

Background notes to the talk on "Control and Management of Public Sector Undertakings" by Vikram A. Sarabhai - Foundation Day Lectures at the Administrative Staff College of India, Hyderabad, India, December 4-5, 1969.

1. Extracts from 'Concepts and Assumptions' from "The Enterprise and its Environment" by A. K. Rice, Tavistock Publications 1963, pp. 12-25.

THE PRIMARY TASK

The Concept

Enterprises perform many tasks at the same time. Industrial commercial enterprises, for example, purchase raw materials, manufacture and distribute products, provide employment, look after their employees, conduct research work, keep accounts, make profits, and pay taxes and dividends; educational institutions train students and provide jobs for teachers. All institutions provide mechanisms at both conscious and unconscious levels for the satisfaction of need and for defence against anxiety.

The number and distribution of tasks vary between and within institutions and over time. Each whole or part has at any given time a primary task - the task that it must, perform to survive.

All industrial enterprises must make profits; public utilities give services. In making profits enterprises may give services, and in giving services a public utility may make profits; but their primary tasks differ, and hence the information on which decisions are made, and the criteria for the judgement of performance, also differ.

The Constraints on Definition and Performance of Primary Tasks

Primary tasks can be defined with varying precision; the more precise the definition, the greater the constraints on task performance. Thus 'to make profits' applies to any industrial or commercial enterprise; and a decision to enter a particular branch of industry or commerce determines the way profits can be made. Every subsequent decision adds further constraints on definition and performance.

Few tasks can be performed in isolation. The environment in which they are performed imposes additional constraints on what can be done and how it can be done. The general constraints are political, economic, legal, and social; the more particular constraints are the human and physical, scientific and technological resources available for performance.

Any practical definition of a primary task must therefore specify the constraints and, moreover, should distinguish between

those that are real and those that are imaginary.

Multiple Tasks with Fluctuating Priority

All enterprises perform many tasks at the same time; in some there is no settled order of priority. Such enterprises can have no one primary task but many, each of which may be primary at any given time. In a teaching hospital, for example, at least two tasks can be defined - to train medical students and to care for patients - both of which are essential for the survival of the institution. In the operating theatre, indeed, task priority may change from moment to moment, depending on the course of the operation. In the same way each part of a large and complex enterprise has its own discrete primary task, which differentiates it from other parts and from the whole, and each contributes to the primary task of the whole. But the contributions are not necessarily equal and can be in conflict. Over-attention to quality in manufacturing for example, can put costs so high as to make the sale of products difficult or even unprofitable. On a larger scale, medical services of heavily populated countries can reduce mortality and sickness, but by so doing they can exacerbate the problems of housing, food production, transport, and employment. Good performance, in other words, of the primary task of one part of a system may make difficult, if not impossible, the performance of the primary tasks of other parts.

has to be accepted that from the organizational point of view activities not directly related to primary task performance are wasteful.

LEADERSHIP

The Primary Task of Leadership

The primary task of leadership is to manage the relations between an enterprise and its environment so as to permit optimal performance of the primary task of the enterprise. For an enterprise the environment consists of its total political, social, and economic surroundings; for a part of an enterprise the environment includes the other parts and the whole.

A leader must define the primary task of the enterprise and keep under constant review both definition and constraints; he must recruit the necessary resources for performance and control their use.

The Leadership Position

Because the primary task of leadership is to regulate the interaction between an enterprise and its environment, the function of enterprise leadership must be located on the boundary between them; and of a part-enterprise on the boundary between the part and the whole. But since each part has its own discrete primary task, the kind of leadership proper to one part may be unsuitable for other parts. The task of overall leadership is, therefore, not only to find an optimal balance between the parts so as to make possible their maximum contribution to primary task performance of the whole, but also simultaneously to distinguish between and to integrate the different leader-follower patterns appropriate to different parts.

Skill of the Leader

Because an enterprise must perform its primary task to survive, a leader must have sufficient knowledge to allow him to make a major contribution to the solution of the problems involved in task performance.

I do not wish to infer that a leader of a market-dominated enterprise, for example, must, of necessity, be a marketing specialist, or of a manufacturing-dominated enterprise, a production specialist, but he must have enough insight and experience to be able to manage the specialists. In practice, there is, therefore, a limit to the delegation of tasks to specialists, and contemporary notions of general management as comprising only administrative

and coordinating functions are largely unreal.

SYSTEMS OF ORGANIZATION

Organization-Task Correspondence

If organization is a means to an end, and the end is primary task performance, then it follows that the most appropriate organization for any enterprise is that giving a best fit to primary task performance.

An organization is therefore most stable when the primary task of the enterprise and the methods of its performance are enduring. Such an organization can then be valued for itself and the values embodied in the culture of the enterprise without inhibiting task performance. But change in the definition of the task or in the constraints on its performance demands re-examination of the related organization to discover whether what had previously been a best fit is still best.

Organization Models

Any enterprise, considered as an open system, can be defined by its imports and exports, that is, by the manifestation of its relations with its environment. The basic model I shall use to analyse organization will be an import-conversion-export model derived from open-system theory. I make the assumption that the organization of any enterprise or institution, or of parts of it, can be accommodated in this basic model.

Any enterprise, or part of an enterprise, has many imports and many exports - materials, people, money, products - but it follows from earlier definitions that the dominant import-conversion-export process is that by which the primary task of the enterprise, or part-enterprise, if performed.

From different assumptions about the environment, and the changing relations between the enterprise and its environment, models based on the different import-conversion-export relationships can be constructed. The models can then be compared with each other and with the existing organization. When an enterprise performs more than one task, and there is no settled order of task priority, a model appropriate to each task must be constructed. Comparison of the models may then lead to the conclusion that compromise is the only possible solution.

A model for the organization of a whole enterprise must, of necessity, take account of the differences in the primary tasks of the parts. When the models corresponding to the different primary

tasks of part-enterprises are incompatible with each other and, because of constraints on task performances, neither definitions nor methods can be changed, then again compromise may be all that is possible. What is important is that the need for compromise should be thoroughly tested. It may be found frequently that organizational consistency is itself an inappropriate and unnecessary constraint. The not uncommon insistence, for example, on identical terms of service and rules of behaviour in departments of an enterprise with quite different primary tasks, such as research and production, may constrain unnecessarily not only throughput but also the recruitment of suitable scientists for research.

Organizational Flexibility

Since change in the environment or in the enterprise may require change in the definition of the primary task or in the methods of its performance, an ideal organization is one that is sufficiently flexible to allow the enterprise to respond to short-term environmental change within the existing frame-work, and to adapt, without major disturbance, to long-term change.

Maximum flexibility within an enterprise is obtained when, consistent with overall integration:

(a) control of parts is by results rather than by detailed inspection;
(b) parts have both 'whole' tasks and maximum autonomy;
(c) communications are selective, rapid, and undistorted.

In practice, these conditions suggest that:

(a) control should be through people rather than through procedures;
(b) those in charge of part-enterprises should have both the responsibility for, and the authority required to carry out, their tasks;
(c) differentiation within the organization should ensure that each level in the hierarchy has a genuinely discrete and distinctive primary task;
(d) so far as is possible, lines of command should be short, with the minimum number of levels consistent with adequate overall control.

Change in organization - the small-scale change that is going on all the time as well as the major upheaval - means changing roles and role relationships, and hence the jobs and personal relationships of those who do them. Such changes can, and usually do, provoke anxiety. Those who work in an enterprise during periods of organizational change are always bothered about the possible consequences of change for themselves and their careers. They want

to know how they will be affected, and where they will stand. Rapid and undistorted communication of definite intention and decision can, therefore, be reassuring, even if, at times, disappointing.

Changes dictated by primary task demand may not be welcomed by, or even possible for, existing members of an enterprise. In practice, therefore, both resistance to change by existing members and the inevitable but proper distaste of replacement may add further constraints and thus strengthen the forces leading to compromise organizational solutions. It is, however, my belief that changes that relate the enterprise more realistically to its environment will, in the long run, provide its members with increased opprotunities to obtain satisfaction from effective task performance, a satisfaction that, so far as their behaviour is adult and reality-based, they are loath to surrender.

Operating Systems

When a complex enterprise is differentiated into parts, the sub-systems that carry out the dominant import-conversion-export process, that is, perform the primary task of the enterprise, are the operating systems. Generally there are three kinds of operating system:

(a) import - the acquisition of raw materials;
(b) conversion - the transformation of imports into exports;
(c) export - the disposal of the results of import and conversion.

In simple organizations there may be incomplete differentiation and one operating system may carry out more than one part of the total process, or even all of it; in complex organizations there may be more than one operating system of each kind. Most organizations will contain a mixture of both simple and complex structures.

The process flow of a relatively simple system is shown in Figure 2. With the total enterprise as the frame of reference there are two import operating systems between them acquiring three raw materials (parallel differentiation based on major differences in sources of raw materials); four conversion systems (differentiated in parallel and in sequence); and two export systems, disposing of six products between them (differentiated in parallel based on major differences in the destination of exports).

But each differentiated operating system has its own primary task and hence its own dominant import-conversion-export process. With the import systems as frames of reference,

their imports are raw materials; the conversion process is the unloading, sorting, and stocking of materials; and exports are the sorted materials to the conversion operating systems. Imports into the conversion systems are either the raw materials from the import operating systems or part-products of other Conversion systems; exports are finished products or part-products. In the export operating systems, imports are finished products and the conversion process is distribution.

As a contrast, one level of analysis of the flow process of a simple holding company is shown in Figure 3. The company's primary task is to make profits from investments; its imports are capital, and its exports dividends and taxes. Raising capital, making investments, and paying dividends are all carried out in one simple primary system. When, as is usual, the investments are in different companies, either as wholly or partially owned subsidiaries, these could be regarded as conversion systems.

SYSTEMS OF MANAGEMENT

First Differentiation

When an enterprise is differentiated into discrete operating systems, its management cannot be contained in any one operating system, and a system external to the operating systems is required to control and service them. This is the managing system. It contains the management of the total enterprise, of each discrete operating system, and any control and service functions that are differentiated from overall management. In more familiar language, 'top management' consists of 'line' managers - the general manager and managers of operating departments, for example, production and sales -and the ' functional' or 'staff' managers in charge of control and service functions, such as finance and personnel.

Figure 4 shows a possible model organization for the enterprise whose process flow was shown in Figure 2. In the managing system three discrete control and service functions (finance, technological, and personnel, corresponding to the resources required for performance) are differentiated from the directorate or general managenent. Enterprise management is shown on the boundary of the enterprise and its environment, operating system management on the boundary between the operating and managing systems. Control and service functions are totally included within the boundary of the managing system, since they are parts of general management.

Orders of Differentiation

The differentiation of any given enterprise into operating systems and a managing system is the first order of differentiation,

and the systems may be defined as first-order operating and managing systems. In a complex enterprise, one or more of the first-order operating systems may be further differentiated. This is the second order of differentiation, and the sub-systems may be defined as second-order operating systems. These also require management, bringing into existence a second-order managing system. This consists of the management of the first - and second order operating systems, and the second-order control and service functions. The manager in charge of a first-order operating system is thus also the head of the second-order managing system. Figure 5 shows a system differentiated into three first-order operating systems, one of which is further differentiated into two second-order operating systems and a second-order managing system.

Second-order operating systems may be differentiated into third-order systems, third-order systems into fourth-order, and so on. The differentiations can be continued until separate operating systems cannot be discretely identified, and primary production systems are reached.

The number of orders of differentiation will depend both upon the complexity of the system and upon the frame of reference of the analysis. By definition, with a primary production system as frame of reference, no differentiation is possible. With a department of a factory containing more than one primary production system, at least a first order of differentiation may be made. With a large and complex industrial organization, five, six, seven, or even more orders of differentiation may be necessary before primary production systems are reached.

Control and Service Functions

The control and service functions differentiated from system management and contained wholly within a managing system must be directed towards the effective performance of the primary tasks of the operating systems they have been set up to control and service - functions that do not serve this purpose have no meaning in organizational terms. It follows that a managing system should contain all the controls and services necessary for the adequate management of the operating systems. More formally:

The greatest operational efficiency is achieved when the functions of control and service are contained in the managing system of the same order as the operating systems controlled and serviced.

The inclusion of a control or service function in a managing system of a higher order than the operating systems controlled or serviced implies a vote of no confidence in the management of the system in which the function should have been included. Conversely, the location of a control or service function in a managing system of a lower order than the operating systems controlled or serviced implies a vote of no confidence in the control or service function. If, for example, the chief engineer reports directly to a managing director, and not to the works manager, there is an implied vote of no confidence (so far as engineering is concerned) in the works manager; by contrast, if a personnel manager is responsible for activities in a sales division as well as in the works, but reports to the works director and not to the managing director, then the vote of no confidence (so far as company personnel policy is concerned) is in the personnel manager.

In practice, because of the economic or technological importance of some functions, or the personal power of one manager vis-a-vis others, or the lack of capacity in some specialist function, control and service functions will often have to be located in what are organizationally inappropriate orders. An analysis based on the correspondence between primary tasks and organization models may go part of the way towards distinguishing between what is practically essential and what is expedient for avoiding an unpalatable, and sometimes painful, confrontation of personal conflicts or inabilities.

2. Note on Representational Membership of Boards of Directors of Public Sector Undertakings, by Dr. Kamla Chowdhry, Indian Institute of Management, Ahmedabad.

I would like to make certain general comments concerning the Boards of Public Sector Undertakings and certain specific comments relating to the provision of a nominee of Labour on the Board of Directors.

General Comments

In considering the Board of Directors, the following aspects need to be kept in mind:

i) Size of Board: The size should be small enough for members to interact in cohesive fashion and large enough to bring in necessary skills and competences required.

ii) Commitment and continuity: The tenure of members should be such as to provide reasonable continuity in the policy-making process of the Board. The commitment to long-term decision can be most fruitfully accomplished if the members are there to see the results of the decision made. There is also a learning process in making policy decisions in relation to the problems of a particular industry or technology. And as such both continuity and commitment of members are important.

iii) Representational Members: Members should be invited to be on Boards for the competence they possess and not because they represent an office. The concept of representational members does not provide the framework for overall consideration of problems. Each representational member has a psychological need to represent the office that nominates him.

Taking the above objectives into account, it is suggested that a small board of five to eight members selected for their professional skills, competence and experience be formed. The kind of Boards that could be considered are:

(a) Internal Boards taking into account different functions
(b) External Boards taking into account different functional specialities
(c) Mixed Boards with external and internal members.

The choice of a Board in any given situation would essentially depend on the availability of men and women with the necessary knowledge, skills, experience, maturity and integrity. The availability of persons either from inside or outside the

Corporation would depend on several factors - the size, scope and diversity of industry; the type of industry, that is, whether it is labour intensive, highly technology-oriented, marketing-oriented and so on.

However, it is significant to point out some implications of the choice that can be made regarding the Board structure.

With an internal Board, the responsibility and accountability would be joint and not of the Chairman or of the Managing Director of the Corporation. In an internal Board, the policy-making and executive group are the same. And as such, the policy-making group will find it difficult to review itself in relation to its executive tasks. On the other hand, there will be greater chances of continuity, commitment and professional judgement in the decision-making processes.

With a fully external Board, although the responsibility and accountability of the chief executive is clear cut, there could be problems of finding persons with sufficient commitment to the enterprise.

A mixed Board could create internal problems of coordination since the signals are that some functions are more important than others. If, however, there are non-functional members from inside the Corporation, the above problem is not likely to arise.

Specific comments

The assumption of the provision that there should be a nominee of Labour on the Board of Directors is that in over-all decision-making an important aspect is the human factor. This objective is certainly worth considering since any major decision would have three inter-related aspects - technology, finance and human beings. However, the Director seems to equate professional knowledge concerning the human factor to experience in trade union and/or administrative experience in the Labour. This is a questionabl assumption. What is desired is to find a person who can bring to bear the human relations point of view in policy-making.

Giving importance to labour representation on the Board of Directors might encourage supervisory and managerial cadres to form collective groups for negotiations. The labour aspect certainly needs to be emphasised but in relation to a totality of the system. Persons either professionally trained in human relations or having a broader experience dealing with communities and

groups may bring in a disciplined and sensitive approach to the problem of the human factor in industry.

Since labour unions in India are politically oriented and since there are often rival unions at the workers' level, recognition of one union at the policy-making level would, it is feared, not only bring political aspects in decision-making but would create conditions of rivalry and conflict at the workers' level.

FIGURE 2 *PROCESS FLOW ANALYSIS OF A RELATIVELY SIMPLE ENTERPRISE*

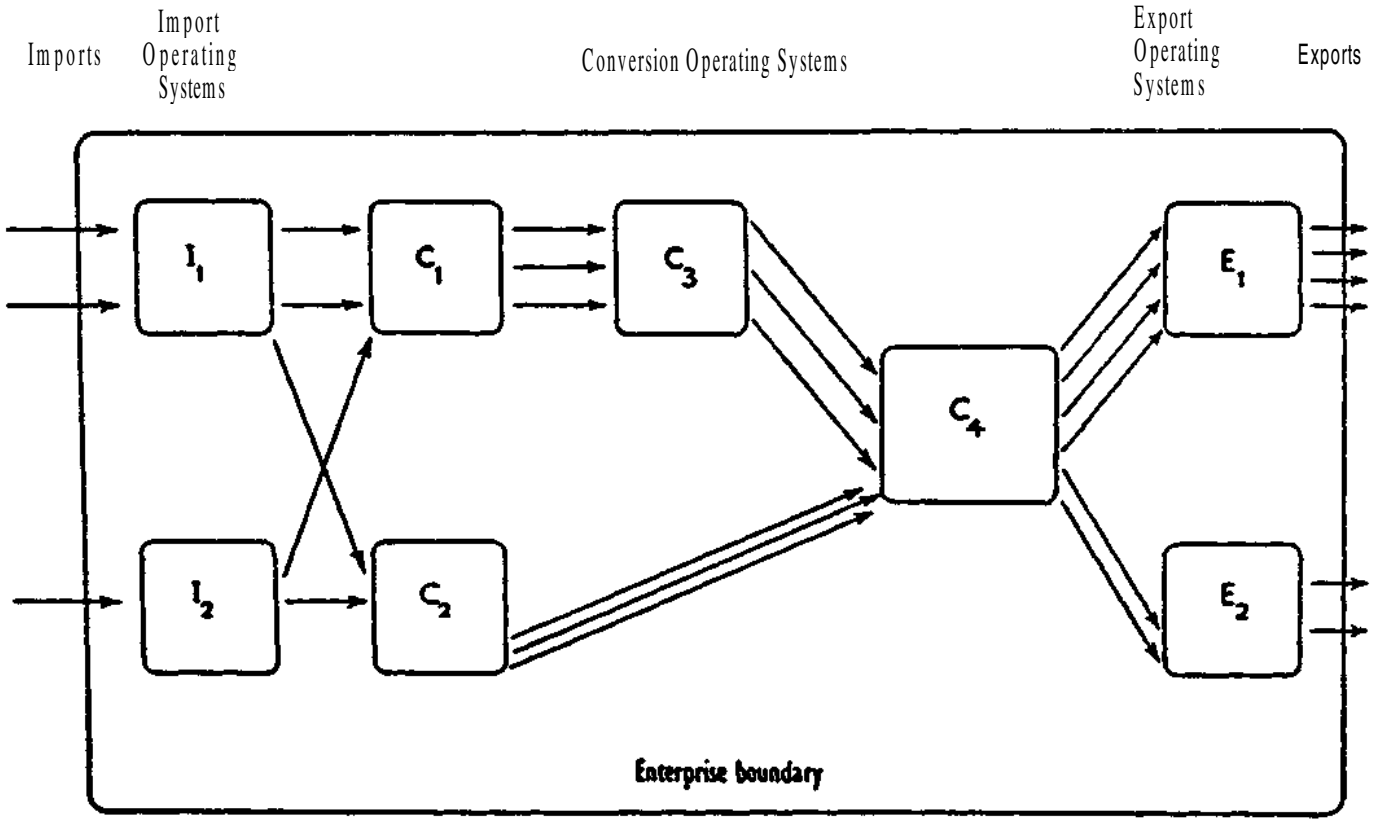
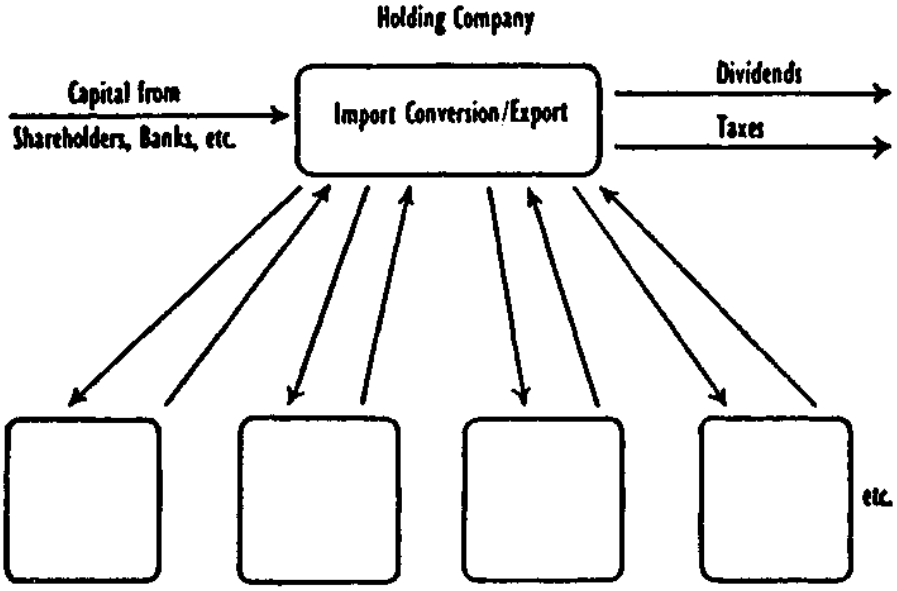


FIGURE 3 PROCESS *FLOW ANALYSIS Of A SIMPLE HOLDING COMPANY*



Wholly or Partially Owned
Subsidiaries

FIGURE 4 *MODEL ORGANIZATION OF* THE *ENTERPRISE SHOWN IN FIGURE 2*

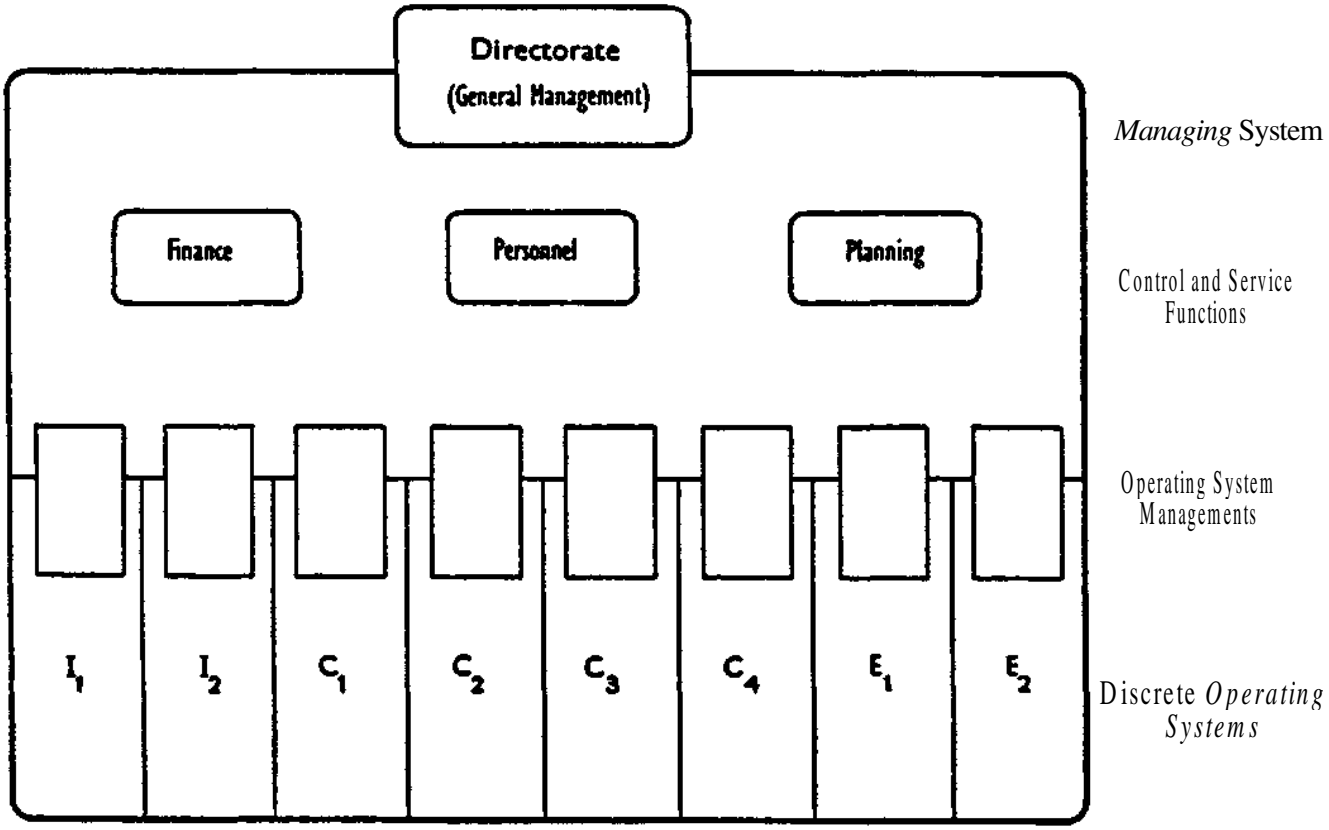
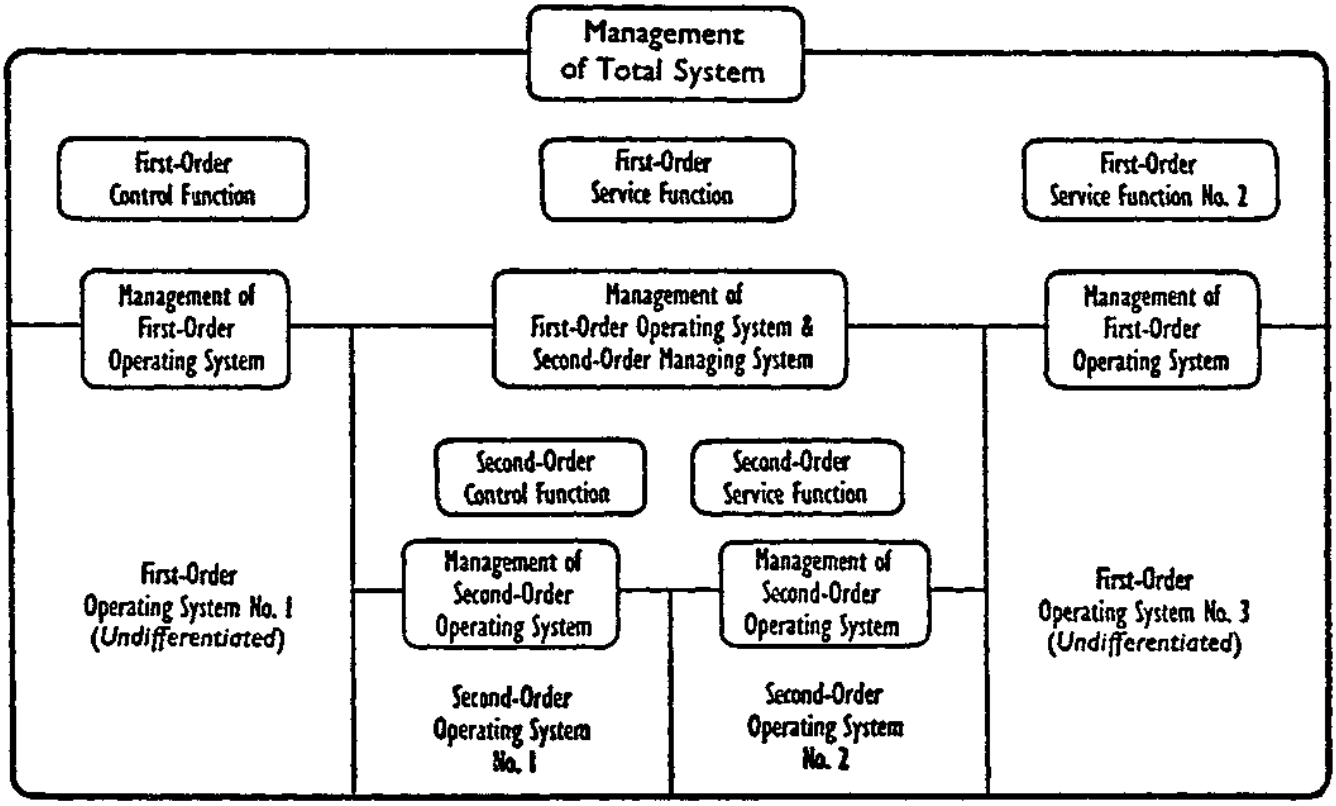


FIGURE 5 *OPERATING AND MANAGING* SYSTEMS OF THE *FIRST AND SECOND ORDERS OF DIFFERENTIATION*



MANAGEMENT SYSTEMS BASED OK A COMPARATIVE ANALYSIS

Operating characteristics	System of Organization			
	Authoritative			Participative
	Exploitive authoritative	Benevolent authoritative	Consultative	Participative group
1. Character of motivational forces.				
a. Underlying motives tapped	Physical security, economic security, and some use of the desire for status.	Economic and occasionally ego motives, e.g. the desire for status.	Economic, ego, and other major motives, e.g. desire for new experience.	Full use of economic, ego, and other major motives, as, for example, motivational forces arising from group processes.
b. Manner in which motives are used	Fear, threats, punishment, and occasional rewards	Rewards and some actual or potential punishment	Rewards, occasional punishment, and some involvement.	Economic rewards based on compenstation system developed through participation. Group participation and involvement in setting goals, improving methods, appraising progress toward goals etc.

(1)	(2)	(3)	(4)	(5)
c. Kinds of attitudes developed toward organization and its goals.	Attitudes usually are hostile and counter to organization's goals	Attitudes are sometimes hostile and counter to organization's goals and are sometimes favourable to the organization's goals and support the behaviour necessary to achieve them	Attitudes may be hostile but more often are favourable and support behaviour implementing organization's goals.	Attitudes generally are strongly favourable and provide powerful stimulation to behaviour implementing organization's goals.
d. Extent to which motivational forces conflict with or reinforce one another.	Marked conflict of forces substantially reducing those motivational forces leading to behavior in support of the organization's goals	Conflict often exists; occasionally forces will reinforce each other, at least partially	Some conflict, but often motivational forces will reinforce each other	Motivational forces generally reinforce each other in a substantial and cumulative manner
e. Amount of responsibility felt by each member of organization for achieving organization's goals	High levels of management feel responsibility; lower levels feel less. Rank and file feel little and often welcome opportunity to behave in ways to defeat organization's goals	Managerial personnel usually feel responsibility; rank and file usually feel relatively little responsibility for achieving organization's goals	Substantial proportion of personnel feel responsibility and generally behave in ways to achieve the organization's goals	Personnel feel real responsibility for organization's goals and are motivated to behave in ways to implement them

(1)	(2)	(3)	(4)	(5)
f. Attitudes toward other members of the organization	Subservient attitudes towards superiors coupled with hostility toward peers and contempt for subordinates; distrust is widespread	Subservient attitudes toward superiors; competition for status resulting in hostility toward peers; condescension toward subordinates	Cooperative, reasonably favourable attitudes toward others in organization; may be some competition between peers with resulting hostility and some condescersion toward subordinates	Favourable, cooperative attitudes throughout the organization with mutual trust and confidence
g. Satisfactions derived	Usually dissatisfaction with membership in the organization, with supervision, and with one's own achievements	Dissatisfaction to moderate satisfaction with regard to member-ship in the organization, supervision, and one's own achievements	Some dissatisfaction to moderately high satisfaction with regard to membership in the organization, supervision, and one's own achievements	Relatively high satisfaction throughout the organization with regard to membership in the organization, supervision, and one's own achievements
2. Character of communication process				
a. Amount of interaction and communication aimed at achieving organization's objectives	Very little	Little	Quite a bit	Much with both individuals and groups

(1)	(2)	(3)	(4)	(5)
b. Direction of information flow	Downward	Mostly downward	Down and up	Down, up, and with peers
c. Downward communication				
(1) Where initiated	At top of organization or to implement top directive	Primarily at top or patterned on communication from top	Patterned on communication from top but with some initiative at lower levels	Initiated at all levels
(2) Extent to which communications are accepted by subordinates	Viewed with great suspicion	May or may not be viewed with suspicion	Often accepted but at times viewed with suspicion. May or may not be openly questioned	Generally accepted, but if not, openly and candidly questioned
d. Upward communication				
(1) Adequacy of upward communication via line organization	Very little	Limited	Some	A great deal
(2) Subordinates' feeling of responsibility for initiating accurate upward communication	None at all	Relatively little, usually communicates "filtered" information but only when requested. May "yes" the boss	Some to moderate degree of responsibility to initiate accurate upward communication	Considerable responsibility felt and much initiative. Group communicates all relevant information

(1)	(2)	(3)	(4)	(5)
(3) Forces leading to accurate or distorted information	Powerful forces to distort information and deceive superiors	Occasional forces to distort; also forces for honest communication	Some forces to distort along with many forces to communicate accurately	Virtually no forces to distort and powerful forces to communicate accurately
(4) Accuracy of upward communication via line	Tends to be inaccurate	Information that boss wants to hear flows; other information is restricted and filtered	Information that boss wants to hear flows; other information may be limited or cautiously given	Accurate
(5) Need for supplementary upward communication system	Need to supplement upward communication by spy system, suggestion system, or some similar devices	Upward communication often supplemented by suggestion system and similar devices	Slight need for supplementary system; suggestion system may be used	No need for any supplementary system
e. Sideward communication, its adequacy and accuracy	Usually poor because of competition between peers and corresponding hostility	Fairly poor because of competition between peers	Fair to good	Good to excellent
f. Psychological closeness of superiors to subordinates (i.e. how well does superior know and understand problems faced by subordinates?)	Far apart	Can be moderately close if proper roles are kept	Fairly close	Usually very close

(1)	(2)	(3)	(4)	(5)
(1) Accuracy of perceptions by superiors and subordinates	Often in error	Often in error on some points	Moderately accurate	Usually quite accurate
3. Character of interaction influence process				
a. Amount and character of interaction	Little interaction and always with fear and distrust	Little interaction and usually with some condescension by superiors; fear and caution by subordinates	Moderate interaction, often with fair amount of confidence and trust	Extensive, friendly interaction with high degree of confidence and trust
b. Amount of cooperative teamwork present	None	Virtually none	A moderate amount	Very substantial amount throughout the organization
c. Extent to which subordinates can influence the goals, methods, and activity of their units and departments				
(1) As seen by superiors	None	Virtually none	Moderate amount	A great deal
(2) As seen by subordinates	None except through "informal organization" or via unionization	Little except through "informal organization" or via unionization	Moderate amount both directly and via unionzation	Substantial amount both directly and via unionization

(1)	(2)	(3)	(4)	(5)
d. Amount of actual influence which superiors can exercise over the goals, activity and methods of their units and departments	Believed to be substantial but actually moderate unless capacity to exercise severe punishment is present	Moderate to somewhat more than moderate, especially for higher levels in organization	Moderate to substantial, especially for higher levels in organization	Substantial but often done indirectly, as, for example, by superior building effective interaction influence system
e. Extent to which an adequate structure exists for the flow of information from one part of the organization to another, thereby enabling influence to be exerted	Downward only	Almost entirely downward	Largely downward but small to moderate capacity for upward and between peers	Capacity for information to flow in all directions from all levels and for influence to be exerted by all units on all units
4. Character of decision-making process				
a. At what level in organization are decisions formally made?	Bulk of decisions at top of organization	Policy at top, many decisions within prescribed framework made at lower levels	Broad policy and general decisions at top, more specific decisions at lower levels	Decision-making widely done throughout organization, although well integrated through linking process provided by overlapping groups

(1)	(2)	(3)	(4)	(5)
b. How adequate and accurate is the information available for decision-making at the place where the decisions are made?	Partial and often inaccurate information only is available	Moderately adequate and accurate information available	Reasonably adequate and accurate information available	Relatively complete and accurate information available based both on measurements and efficient flow of information in organization
c. To what extent are decision-makers aware of problems, particularly those at lower levels in the organization?	Often are unaware or only partially aware	Aware of some, unaware of others	Moderately aware of problems	Generally quite well aware of problems
d. Extent to which technical and professional knowledge is used in decision-making	Used only if possessed at higher levels	Much of what is available in higher and middle levels is used	Much of what is available in higher, middle, and lower levels is used	Most of what is available anywhere within the organization is used
e. Are decisions made at the best level in the organization so	far			
(1) Having available the most adequate and accurate information bearing on the decision?	Decisions usually made at levels appreciably higher than levels where most adequate and accurate information exists	Decisions often made at levels appreciably higher than levels where most adequate and accurate information exists	Some tendency for decisions to be made at higher levels than where most adequate and accurate information exists	Overlapping groups and group decision processes tend to push decisions to points where information is most adequate or to pass the relevant information to the decision-making

(1)	(2)	(3)	(4)	(5)
(2) The motivational consequences (i.e. does the decision-making process help to create the necessary motivations in those persons who have to carry out the decision?)	Decision-making contributes little or nothing to the motivation to implement the decision, usually yields adverse motivation	Decision-making contributes relatively little motivation	Some contribution by decision making to motivation to implement	Substantial contribution by decision-making processes to motivation to implement
f. Is decision-making based on man-to-man or group pattern of operation? Does it encourage or discourage teamwork?	Man-to-man only discourages teamwork	Man-to-man almost entirely, discourages teamwork	Both man-to-man and group, partially encourages teamwork	Largely based on group pattern encourages teamwork
5. Character of goal-setting or ordering				
a. Manner in which usually done	Orders issued	Orders issued, opportunity to comment may or may not exist	Goals are set or orders issued after discussion with subordinate(s) of problems and planned action	Except in emergencies, goals are usually established by means of group participation

(1)	(2)	(3)	(4)	(5)
b. To what extent do the different hierarchical levels tend to strive for high performance goals ?	High goals pressed by top, resisted by subordinates by subordinates	High goals sought by top and partially resisted	High goals sought by higher levels but with some resistance by lower levels	High goals sought by all levels , with lower levels sometimes pressing for higher goals than top levels
c. Are there forces to accept, resist or reject goals ?	Goals are overtly accepted but are covertly resisted strongly least a moderate degree	Goals are overtly accepted but often covertly resisted to at	Goals are overtly accepted but at times with some covert resistance	Goals are fully accepted both overtly and covertly
6. Character of control processes				
a. At what hierarchical levels in organization does major or primary concern exist with regard to the performance of the control function?	At the very top only top	Primarily or largely at the	Primarily at the top but some shared feeling of responsibility felt at middle and to a lesser extent at lower levels	Concern for performance of control function likely to be felt throughout organization

(1)	(2)	(3)	(4)	(5)
b. How accurate are the measurements and information used to guide and perform the control function, and to what extent do forces exist in the organization to distort and falsify this information?	Very strong forces exist to distort and falsify; as a consequence, measurements and information are usually incomplete and often inaccurate	Fairly strong forces exist to distort and falsify; hence measurements and information are often incomplete and inaccurate	Some pressure to protect self and colleagues and hence some pressures to distort; information is only moderately complete and contains some inaccuracies	Strong pressures to obtain complete and accurate information to guide own behaviour and behaviour of own and related work groups; hence information and measurements tend to be complete and accurate.
c. Extent to which the review and control functions are concentrated	Highly concentrated in top management	Relatively highly concentrated, with some delegated control to middle and lower levels	Moderate downward delegation of review and control processes; lower as well as higher levels feel responsible	Quite widespread responsibility for review and control, with lower units at times imposing more rigorous reviews and tighter controls than top management
d. Extent to which there is an informal organization present and supporting or opposing goals of formal organization.	Informal organization present and opposing goals of formal organization	Informal organization usually present and partially resisting goals	Informal organization may be present and may either support or partially resist goals of formal organization	Informal and formal organization are one and the same; hence all social forces support efforts to achieve organization's goals

(1)	(2)	(3)	(4)	(5)
7. Performance characteristics				
a. Productivity	Mediocre productivity	Fair to good productivity	Excellent productivity	
b. Excessive absence and turnover	Tends to be high when people are free to move	Moderately high when people are free to move	Moderate	Low
c. Scrap loss and waste	Relatively high unless policed carefully	Moderately high unless policed	Members themselves will use measurements and other steps in effort to keep losses to a minimum	
d. Quality control and inspection	Necessary for policing	Useful for policing	Useful as a check own efforts	Useful to help workers guide

EMPLOYMENT AND DEVELOPMENT

By

VIKRAM A. SARABHAI

EMPLOYMENT AND DEVELOPMENT

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1. *The problem of unemployment:*

Every young person and every parent regards education as a means of acquiring he background necessary for a purposeful existence. To complete 11 years of education with a School Leaving Certificate or 15 years with a graduate degree and then be unemployed must surely arouse in the persons concerned a most dangerous attitude towards the "establishment". In this frame of mind, "education" itself appears rather irrelevant. Redundancy of the individual in society associated with unemployment must lead to senseless action and generates a threat to the security of the nation, far greater than what is posed by nations hostile to us. We need therefore to undertake measures to significantly ameliorate the situation, recognising it as a national emergency of the first magnitude.

2. *The magnitude of the problem:*

Official quantitative estimates of this problem do not appear to be available, either for the present or related to any particular period of time in the past. The tragic absurdity of this situation seems to convey to me a deliberate ostrich like act of putting our heads underground. In the absence of good estimates, we must rely on "order of magnitude" considerations, much as astronomers do, to give us insights to the problem. It is easy to shoot down such figures and in the process confuse the main issue. However, I would hope that the total profile of the problem is not allowed to be obscured on the ground that the estimates may be inaccurate by a factor of two.

The Third Plan document had placed the backlog of unemployment at the end of the Second Plan at 9 million (of whom a million were believed to be matriculates) and had estimated an addition of 3 millions during the Plan period. The level of unemployment is certainly rising steadily because the employment opportunities currently being created through the growth of the economy fall far short of absorbing some 15 lakh matriculates and 3 lakh graduates being turned out every year.

In the process of education, if annually the direct cost is Rs. 100 at the school level and Rs. 400 in college, the 1.5 million matriculates and 0.3 million graduates each year carry a past investment of about Rs. 250 crores. These represent a capital *asset,* if we choose to put them to productive use. If we were to build a large steel plant each year and then, after employing thousands of people in it, have no production coming out of it at all, the situation would be less ruinous than the loss that accrues on the investment on our

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educated young men by not putting them to work on meaningful tasks.

Even when they are unproductive, society has to house, clothe and feed the unemployed. They, therefore, also constitute a significant overhead on our economy. If we take Rs. 100 per month as the bare cost that each such "educated" person imposes, we have an overhead estimated at Rs. 180 crores per year.

3. *The "Go/No Go" decision:*

In a manufacturing company, we have different products, each with its own variable cost of production, selling price and gross margin of profit. For some products, the gross margin of profit is often less than the proportionate overhead which should be debited to that product. In theory, therefore, taking the total costs attributable to a product, one would conclude that some products are making a loss and one might be inclined to delete them from the manufacturing programme. A trivial examination however shows that unless there are other special constraints involved, the deletion of the products would increase the company's loss rather than reduce it, because less of the overhead would now be absorbed than before. The cost of unemployed persons constitutes a fixed overhead and any productive use that one can put these persons to, would help the economy and would represent a net gain provided other physical inputs, besides labour, do not cost more than the value of the finished project/product.

4. *The needs and resources of society:*

When we think of putting to productive use the unemployed, we must undertake tasks which are needed by society. In the past, the Plans have largely been formulated in terms of (1) what Government or official agencies can do through expenditure of public funds, and (2) in terms of regulations and incentives related to the private sector. Direct Government initiative and effectiveness is clearly much more in respect of the former. However, since plans related to these are formulated largely by officials, there has steadily grown an attitude amongst the people that they are principally at the receiving end. At a time when resources are scarce and needs are expanding, the paternalistic attitude of Government towards development, benevolent though it may be, fails to generate most valuable inputs that society is capable of making to increase total resources available for development. Increasing the level of direct or indirect taxation and distributing it for the official plans is no substitute for the inputs to development resulting from motivation and commitment of those who are involved at the local situation, where the change is to occur.

5. *Motivation and commitment at the local level:*

The prime necessity is that every group/area should experience perceptible change, from year to year, so that a better future becomes credible and emotional commitment to the task at present becomes possible. This means that something positive, as perceived by the consensus in each group, has to be undertaken. The role of the outside agencies has to be largely supportive, much like that of the owner of a subsidised self-service cafeteria, who presents a menu, from which the customer has to make his choice. Note that in preparing the menu, the owner has already determined the range of choices. The beneficiary has, on the other hand, to exert to get the food, and realises that his choice determines not only what he will receive, but what he will spend.

A menu should only contain items which are realisable in one or two years. Moreover, the "signal to noise ratio" should be good so that the perceptible effects of change are not masked by random fluctuations. For example, the increase in food production due to new seeds or fertilizers should be larger than the usual year to year variations due to vagaries of rainfall, if the farmer is to be convinced that his additional investments are worthwhile.

6. *The derivative of change:*

Another point to bear in mind in preenting a menu is to distinguish between what is desirable and what is attainable. More important than the magnitude of absolute change is that the rate of change, represented by the "derivative", is always clearly positive. Everyone will agree, for example, that it is desirable to provide 400 sq. ft. of plinth area even for the smallest unit of low cost housing. This would cost at least Rs. 5000—more likely Rs. 7000-8000. Multiply this by even the number of Government and public sector employees and those engaged in public works, and one quickly comes to the conclusion that the problem is unmanageable. No action therefore results. On the other hand, if one examines the condition of slum dwellers, they have neither the requisite area nor water, sanitation, electricity or proper roads and communications. To them the provision of an identified plot of land, perhaps no bigger than 500 sq. ft. in extent with a water tap and a toilet, would represent a marked improvement in living conditions. I am told by an architect that this would perhaps cost Rs. 400 which is an order of magnitude smaller than the cost that we would regard for providing a house according to "minimum" standards.

In this country, we fight a losing battle if our development is planned only on quantitative increases, because the population increase constantly erodes growth. It is on the other hand a qualitative change of life which can make progress tangible.

7. *Inputs for development:*

In the proposition which I am suggesting, the most important outside resources to be provided to a community would be:

(a) A *per capita* financial input on a scale inversely related to the existing level of development.
(b) Careful evaluation of choices based on engineering studies and cost-benefit analysis related to local con ditions, available technologies and available physical inputs from out side.
(c) Infra-structure of water, energy, communications and transportation.
(d) Technical training and know-how.

The community's choices would, on the other hand, mainly cover decision-making in the following areas:

(a) Community effort to increase pro ductivity and economic returns.
(b) Housing and civic amenities.
(c) Education.
(d) Health.

8. *A prototype plan for employment and development:*

Essentially the programme hinges on dealing with the problem in comparatively small communities and areas of limited extent, where local leadership can effectively function.

We recognise that even though there are national problems, there are no national solutions and that each area has to choose

a programme most related to its felt needs and most appropriate to the level of commitment which the beneficiaries are willing to make. What is important in this context, however, is the menu that is offered to the community. The preparation of lists of alternative tasks requires scientific methodology applied to felt needs and resources, internal as well as external, which are available to the community. In a metropolitan area, for instance, a typical unit might be one square mile in extent and have perhaps 100,000 inhabitants. It would need a centre for urban development, which could typically have 6 to 10 full time professionals—a civil engineer, a hydraulic or sanitary engineer, a person trained in operations research, a biologist, a physicist/chemist, an economist, a social scientist and a management specialist. Such a group could complete the analysis for the preparation of the menu for each local area in about four months, using local talent on a part-time voluntary basis for survey and field research. These professionals could be drawn from existing public or private organisations including Government, by making it obligatory on the part of all employers to provide up to 10 per cent of their professional staff the opportunity of volunteering for participation in the national scheme with their salaries and jobs protected while they are away for periods not exceeding one year. In the case of public organisations, there would be no need to reimburse the institutions concerned because they certainly have enough fat to be able to manage in a state of emergency with a strength of 90 per cent of their normal complement. In many universities in the West, it is customary to give the faculty members a "sabbatical" period, namely a full academic year after six years, or a half academic year after three years, when they could be completely free from their University responsibilities and could devote themselves to further study, research or any other academic work including writing of books. I believe that much is gained by providing for a voluntary commitment of the faculty members to the problems of national development within the framework as stated here. But if, through experience, it is found that the response is not adequate, the matter could be dealt with on an obligatory basis, much as it was during the last war, when members of the academic staff were directed to work on special projects related to the war effort.

In each area, every educated person who is unemployed should be guaranteed a position on a fixed stipend to work in the projects selected by the local community. In fixing the stipend, one should not attempt to match the "market rate" for the persons concerned. They should, however, in addition be provided shelter (where necessary), food and clothing on standards applicable to the Defence Services. They could live with the stipend at the community project till they find permanent employment and during their work for the project, they should be given intensive training to equip themselves to do the job well.

9. Scientific thought, approach and methodology have potential to make contributions to society of far greater significance than tangible results of technology in terms of products and services, staggering as they are. We have today a very sizable educated professional group which is largely passive in relation to the tasks of development. Its active participation and the commitment of local initiative in each area are, in my opinion, necessary conditions for social progress, political stability and the integrity of the nation.

Welcome Address by Dr.Vikram A.Sarabhai, Chairman, Atomic Energy Commission, on the occasion of the dedication of the Tarapur Atomic Power Station by Prime Minister, Shrimati Indira Gandhi on 19th January 1970.

Prime Minister Indira Gandhi, Chief Minister Naik, Shri Babubhai Patel, Commissioner Ramey, Your Excellencies, Distinguished Guests, Ladies and Gentlemen:

On behalf of the Atomic Energy Commission it is my privilege to welcome you today. Bhabha championed the cause of nuclear energy for the crucial role that it is destined to play in India. He was strongly supported by Shri Jawaharlal Nehru, who ardently believed in the application of science and technology for transforming society. We are privileged that Prime Minister Indira Gandhi is today dedicating Tarapur, the first Atomic Power Station in India.

You, Madam, have continued the great tradition set by your father in supporting science and on behalf of all of us who work for the Atomic Energy Commission, I wish to express our deep appreciation for your guidance and encouragement. Today, we have reached an important milestone in the progress of atomic energy and it conveys to us great warmth that so many of our friends from abroad and from this country have responded to our invitation. I would like to make special mention of Dr.Eklund, Director General of the International Atomic Energy Agency, Mr.Piccagli from the World Bank and the representatives of the Atomic Energy Commissions of countries with which we have close ties particularly, Mr.Timbs from

Australia, Dr.Haywood from Canada, Dr.Goldschmidt from France, Dr.Sudarsono from Indonesia, Dr.Salvetti from Italy, Dr. Brynielsson from Sweden, Sir Charles Cunningham from the United Kingdom, Commissioner Ramey from the United States, Dr.Kraemer from West Germany and Dr.Guzina from Yugoslavia.

While global tenders for the atomic power station at Tarapur were issued as early as October 1960, the Indo-U.S. Agreement for cooperation and the U.S.AID loan agreement were not concluded till late in 1963 and the main contract was awarded to the General Electric Company of U.S.A. only in 1964. The completion of the Station in a period of five years in spite of unexpected technical difficulties which arose during construction is a tribute as much to the main contractor and Bechtel Corporation who were the construction engineers on their behalf as it is to the Tarapur Project Administration of the Department of Atomic Energy backed up by the Bhabha Atomic Research Centre. Nuclear Utility Services and the Kuljian Corporation of India Ltd. were consultants to the Department of Atomic Energy. *I* wish to take this opportunity to thank them all on behalf of the Atomic Energy Commission for the outstanding team work under the leadership provided by Shri M.N. Chakravarti, Project Administrator and Shri M.Dayal, Engineer-in-Charge. The project itself would of course not have been possible but for the very generous financial assistance received from the US AID and technical assistance and advice from the US Atomic Energy Commission. For all this and the particular interest that you, Mr.Ramey, have taken, we are deeply grateful.

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Early in March 1958 two remarkable resolutions were made by the Government of India. The Scientific Policy Resolution announced, and I quote: "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.

Science 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 extenaed man's mental horizon. It has thus influenced even the basic values of life, and given tin civilisation *a* new vitality and a new dynamism.

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".

The resolution was preceded four days earlier by another relating to the constitution of the Atomic Energy Commission which stated : " ... India should be able to produce all the basic materials required for the utilisation of atomic energy

and build a series of atomic power stations, which will contribute increasingly to the production of electric power in the country. These developments call for an organisation with full authority to plan and implement the various measures on sound technical and economic principles and free from all non-essential restrictions or needlessly inelastic rules. The special requirements of atomic energy, the newness of the field, the strategic nature of its activities and its international and political significance have to be borne in mind in devising such an organisation."

The unmistakable hand of Shri Jawaharlal Nehru and of Homi Bhabha can be clearly seen behind these resolutions.

For the management of Tarapur as a Project, Bhabha created a special Board which was presided over by the Project Administrator and had as its members three leading scientist/ engineers from the Bhabha Atomic Centre as well as an administrator from the Department of Atomic Energy. This Board has shouldered heavy responsibilities for Government decisions related to the project and the smooth progress of the project is in no small measure due to the efficiency and dedicated work put in by the members of the Tarapur Board. The Board has also provided a link with the Bhabha Atomic Research Centre which has borne the brunt of providing not only men with special skills but technical advice and specialised services as required. Moreover, extensive back-up of a programme for safety in the Tarapur environment has also been

undertaken through this link with our Bhabha Atomic Research Centre. In future the operation and maintenance of this Station would be the responsibility of an Atomic Power Authority which is to be newly created under the Atomic Energy Commission. But the pattern of organisation that was evolved for Tarapur in its project phase has served as a model for later atomic power projects and the other industrial projects for nuclear fuel and heavy water.

In our country with scarce resources, it is understandable if every investment is examined in terms of the returns it can bring. It is moreover a good discipline for all of us to have an eye on the capital costs of our first nuclear power stations and the price at which electricity can be sold. But in examining the direct financial aspects, particularly for *a* project such as the Madras Atomic Power Station which we are for the first time undertaking entirely on our own, let us note that we are not merely building power stations but also creating new national capability of great economic significance in the long run.

During the past two days, at the Seminar on Nuclear Power conducted by the Atomic Energy Commission, we have discussed the energy needs in this country and the role of nuclear power as well as its development both here and among the other atomically advanced countries abroad.

"Electrification, Lenin had said, will make it possible to place the country's economy, including agriculture, on a

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new technical basis, on the technical basis of modern large-scale production. Only electricity can constitute such a basis." There is a remarkable correlation between per capita gross national product and the per capita energy consumption for the nations of the world. Developing nations and particularly India are at the bottom of the ladder and the industrially advanced countries at the top. Correlations do not necessarily signify a direct cause and effect relationship but let us make no mistake about the fundamental necessity of energy to increase human productivity in agriculture, as in industry.

India has been fortunate in achieving during the first three Plan periods a doubling time of five years for its installed generating capacity. This corresponds to a compound growth rate of 15 per cent per annum. Any growth rate of installed power on a smaller scale, in the context of the inevitable growth of population during the next 20 years in spite of the most energetic measures which we might take for population control, is bound to constitute a serious impediment to national development and the eradication of poverty. There would be need in India for fresh installed generating capacity of at least 20,000 MW during the second half of the 70's and of 40,000 MW from 1980 to 1985, totalling 60,000 MW for the decade commencing 1975. Conservative estimates involve a capital investment of Rs.12,000 crores in electric power plants alone. It is well-known that the economic penalty involved in pessimistic planning of electrical capacity is many times greater than the penalty arising from optimistic

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planning. In any case, realising that 3 to 7 years are involved in the building of power stations, it is not hard to see why firm planning only on a five year basis for our energy needs repeatedly leads us into serious trouble. If for instance, the industrial establishments which would be called upon to supply annually about Rs.800 crores of equipment during the decade commencing 1975 do not prepare themselves during the next three or four years with the design capability and the trained personnel of the shop-floor we would either have no development or go out with & begging bowl for external assistance of a magnitude which is in any case unlikely to be forthcoming. Moreover, the types of equipment required in the late 70's in terms of technology and size should be chosen for development now if we are not to fall flat on our faces in the task that we have undertaken. What applies to power in general applies equally to nuclear power which should expand at the rate of three times every five years if by 1985 it is to reach a figure of about 8500 MW, constituting about 12 to 13 per cent of the total generating capacity in the country. Business in supplying components for the nuclear power plants should be about Rs.100 crores annually during the latter half of the new decade.

A good example of the role that nuclear power can play can be seen from our most recent study on the feasibility on an agro-industrial complex in three districts of western Uttar Pradesh, having collectively a population of about 24 million. We can derive a return of 81 per cent on the incremental investment of approximately Rs.1000 crores with 400 MW

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nuclear power energising 24,000 additional tubewells and producing elemental phosphorus for fertiliser using an electro-thermic process. Almost half the investment is on what might be termed the infrastructure, involving capital expenditure on augmenting roads and railway transportation, new warehouses, agricultural implements and for providing credit to farmers. The programme would generate all the year round direct employment on farms for 1.4 million persons, resulting in additional agricultural production of 22 million tons and an increase in the gross national product by about Rs.1000 crores annually. The profit to the agriculturist is likely to be about Rs.4500 per hectare after paying full wages for all labour employed. These figures, dramatic and almost incredible can be understood if we recognise that what we have in fact done here is to use nuclear power as a catalyst, through the water that it pumps up, and the fertiliser that it produces, for harnessing through ohoto synthesis the vast solar energy falling on the plains of India. The example provides a striking demonstration of the impact that the supply of energy can produce in our countryside where the largest number of under-privileged persons of India reside. To realise the potentialities for the accelerated development of our country we need to clearly understand the role of energy and of water and adopt appropriate policies with determination and commitment. Time does not permit me to elaborate these matters in details but I will cite the most important as illustrations.

First we need to exploit underground water resources cooperatively or through local or State Government

organisations rather than by individual farmers if we are to optimize the use of these resources with minimum capital and operating costs and spread their benefits equitably to all farmers. There could be a saving of up to 70 per cent in capital costs for the wells and the power supply system if such a policy is adopted.

Second, in order to take advantage of the economies resulting from generating power in large units and using advanced technologies, particularly nuclear power, there should be a re-allocation of responsibility as between the Centre and the State Governments to provide for the establishment of new ones and the operation of all large generating stations exclusively by the Centre. It seems that the optimum solution will involve the establishment by the States of "Seed" units of small capacities upto perhaps 10 MWe which could be moved from one place to another after the local load has developed and can be connected to a major grid. Third, the States should have responsibility for the net-work of secondary transmission lines for rural electrification. However, the Centre should take responsibility for interconnecting principal grids for transmitting bulk power from one area to another.

Further, recognising that nuclear power is today essential for economically supplying energy in large parts of the country, and is moreover the only major supply on which we will need to fall back in perhaps less than $0 years time, we need to commit ourselves to an appropriate programme of atomic power stations. We cannot hope to gain all the

great economic advantages of nuclear power unless we develop a mix of thermal and advanced fast breeder reactors.

It is my firm belief that the problems of poverty and regional imbalances in our country cannot be effectively tackled without a rational national policy for energy. The dream of Jawaharlal Nehru and Bhabha that atomic energy will be fully competitive with other forms of energy even in the first station that we build is today being realised at Tarapur, and it is my privilege to request you, Prime Minister, to dedicate the Station and usher the age of nuclear power in India.

NATIONAL CONFERENCE ON ELECTRONICS

Opening Remarks

by

Dr Vikram Sarabhai Chairman,
Electronics Committee Government
of India

March 24, 1970

On behalf of the Electronics Committee of the Government of India I have pleasure in welcoming you to the first National Conference on Electronics.

The late Dr. Homi Bhabha was quick to recognise, soon after the Chinese invasion of 1962, the appalling dependence of this country on foreign sources in the whole field of electronics, so vital not only to Defence, but also to national development. The Department of Atomic Energy appointed a Committee in August 1963 with Dr. Bhabha as Chairman and three other members, who are all here today, Dr. A.S. Rao, Dr. Bhagavantam and myself. We were assisted by a large number of representatives from user Ministeries of Government, from research and development organisations and also from industry. The Report of the Bhabha Committee, which was completed by Dr. Bhabha just prior to his tragic death early in 1966, is one of his most memorable contributions.

Since 1966, the subject of Electronics has been allocated to the Department of Defence Supplies and an Electronics Committee has been created by Government to take account of the most urgent needs for the rapid development of electronics, keep track of the research being done in design and development, identify the sectors where indigenous production could be built up, and promote the speedy building up of such capacity. The National Conference on Electronics, coming four years after the acceptance by Government of the Bhabha Committee's Report is timely.

How shall we take stock of the situation ? By recounting the figures of production of electronics equipment against some of the targets that were visualised or, alternatively, in terms of the qualitative change that was expected if certain policy recommendations were faithfully adopted and initiatives expeditiously undertaken?

In quantitative terms one can summarise the picture as follows:

1) The biggest progress has been seen in the entertainment industry, along with the indigenous production of entertainment grade components. Here the quantitative performance

has even exceeded targets, but the prices of components or the sets are rarely competitive on international standards.

2) We have a very poor performance in attaining self-sufficiency in Defence Electronics or in electronics for telecommunications - the two fields which were within the direct scope of Government initiatives. It is mainly in professional grade equipment for atomic energy and in some fields of telecommunications that indigenous R & D has made significant contributions to self-sufficiency.

3) In basic raw materials, we have fallen much behind the targets.

There may be different ways of looking at this picture. I would leave the judgement to each of you. I would make my point by reading some paragraphs which are drawn from the Bhabha Committee's Report. I quote:

"The electronic industry has to be considered as a whole and developed in an integrated and interlocked manner. If the public interest as also the interest of the Indian tax-payer, (who after all foots the bill for all military equipment) is to be considered, it is essential that all equipment, whether for civilian or military use, should be produced in the most economical manner possible. This requires that the production of such equipment should be organised according to technologies and economics of production, as is done in the highly industrialised countries. If the separation of civil and military production is not required by security considerations even in the technically most advanced countries, it clearly cannot be justified in India. It also follows from technological considerations that production in the public sector cannot be separated from production in the private sector and for optimum development of the industry it is necessary to plan it on an integrated basis taking the public and private sectors together." Today the vast majority of our production of professional equipment is conducted under monopolistic conditions with no competition even amongst independent public sector companies. In spite of the electronics industry being intensive in skilled personnel and Our paying salaries much below those in other foreign countries advanced in electronics, we rarely match the price of imported goods.

The Bhabha Committee has said: "In electronics, more than in any other industry, technical persons must be in key positions at all levels, from policy making and the management of plants down to the individual production operations. The committee is convinced that the

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necessary scientific and technical personnel required to develop the industry at the pace suggested, can be found in India without great difficulty." Do we have technocrats in our set up today at the topmost level of executive decision making affecting the choice of new technologies, the creation of R & D and production facilities, the licensing of industries or the import of equipment and foreign technology?

The Report continues: "In order to develop a self-reliant and largely self-sufficient industry capable of meeting Indian needs and of competing in the world market the first and most urgent requirement is to establish in every plant producing electronic equipment, scientific and technical design and development groups with sufficient competence to redesign equipment either being manufactured under licence or whose design is readily available in the literature, in order to adapt it to Indian conditions and to use the components available in India. These groups should also bring prototypes developed in the country to the production stage. In all such work a considerable saving in development time can be effected by dismantling imported equipment and copying its design with such modifications as may be necessary to adapt it to Indian requirements. It should be possible within the relatively short period of about a year to redesign equipment or to develop indigenous prototypes from information available in the literature or obtainable from studying foreign models. It is essential that action should be taken simultaneously to design, develop and produce the next generation of equipment indigenously". Note the time period of one year. Have we followed this approach in any large measure? If we had, why is it necessary to resort to importation and to foreign collaboration for so many major systems and items in defence and telecommunications, even five years after the report was completed? Moreover, have we even formulated our own specifications of the next generation of equipment that we will need?

The Bhabha Report says: "In developing systems which are well known, it is possible to split the job between a: number of separate development groups. It is not necessary that these development groups working on various aspects of a large system should be located in one institution. It is, however, essential that one person or group should be made responsible for directing their efforts towards a unified system design". Is there any appreciation of this?

The Report points out: "The very backwardness of the country in electronics and the smallness in size of the present electronics industry could be turned into an asset, if early stages in the development of the industry in other countries are by passed and the industry is planned on the basis of the latest ideas and techniques. In no circumstances should India follow step by step the development of the electronics industry in the more advanced countries, entailing, as this would

inevitably, the production of obsolete components and equipment and the use of obsolete and obsolescent techniques and production processes" The distance between this and reality is illustrated by the tremendous resistance of users to look seriously at point-to-point and mass communications through synchronous satellites, which have revolutionised the field in recent years.

The Report urged: "In the electronics industry self-sufficiency depends, to a large extent, on the indigenous availability of primary materials. Where a lack of mineral resources does not make it impossible, it should be the definite policy to make the country self-sufficient in primary materials within five years, and in important materials within three years". This period is already passed.

The Report commented: "It has been found that the economics of scale and the removal of customs duty on imported primary materials for making components or their production in the country, will straight-away effect a 40 per cent reduction in the price of certain components, while a further increase in the scale of production will reduce the cost still further". Import duties continue and today Indian electronic components are amongst the most expensive in the world This is a factor gravely affecting our ability to export finished equipment at competitive prices.

Perhaps the most significant comment in the Report is: "A very large part of the expertise required to design systems, develop equipment and undertake their manufacture is currently available in the country. It is, therefore, quite realistic to base the next generation of equipment, that which will come into use between 1970-1975 - entirely on indigenous designs. Thus building up a self-sustaining electronics industry in the country within a decade, is possible if development work and progressive switch over of both production and use of indigenously designed and developed equipments is decided upon immediately by Government, as an inflexible policy to be followed with determination.;

Where development is in an advanced stage and where the executive technical authority is satisfied with the ability and capability of the agency to develop and produce the equipment to desired specifications a calculated risk should be taken and firm orders placed on that agency while the equipment is still under development. This will help to considerably telescope the period involved in the procurement of components and the availability of equipment to users. In the initial stages, it is recommended that these procedures be confined to Government agencies. It will be appreciated that these instruments cannot be classified as lethal stock and therefore, a calculated risk at an appropriate stage will save considerable time".

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As Chairman of the Electronics Committee, I must accept responsibility within Government with my colleagues and the Ministry* It is precisely because of this responsibility that I must frankly note the handicap when developmental tasks are looked upon as beginning and ending with regulation and licensing under beaurocratic control. Innovative leadership is not to be confused with administration by generalists, however motivated and dedicated they may be. One needs technical judgement, not merely coordination; commitment to a long range task of growth, not those who move from one job to another every 3 to 5 years. There is largely a non-appreciation of the distinction between systems design and responsibility on the one hand and the manufacture and supply of individual pieces of equipment and components on the other. The primary need, I would suggest, is for an explicit acceptance of the principles which I have quoted here, and for formulating policy and executive decisions which pursue these principles relentlessly. How far we are from the goal can be judged by the tens of crores of rupees worth of professional equipment still being contracted from abroad in the year 1970, when the Bhabha Committee had talked of one and three years for reaching self-sufficiency. If Government is to play a more effective role than it has so far, we should correct some elementary handicaps.

The almost total lack of primary data on production, sales, imports, research and development activities, has been one of the most serious handicaps facing the Electronics Committee. Not only is little data available, but even that has to be collated from a large number of agencies, which make no effort to ensure that rapid retrieval is possible. Moreover, the sources collect data on the basis of self-generated categories and so any inter-comparison between them becomes impossible.

Moreover since extreme specialisation is another dominant characteristic of electronics, it is very difficult for a single person or even a small group to keep fully and continually abreast of developments in a whole range of technologies, solely through their own efforts. Consequently, a technologically and commercially meaningful evaluatory function can be achieved, only when scientists and engineers, actually engaged in design development and engineering activities are "pulled-in" to undertake detailed examination of applications for industrial licences.

In a fast growing industry in which doubling time is 2 - 3 years, targets of licensed capacity should represent minimum levels to be reached rather than the limits within which production must be framed. Moreover we should unambiguously declare the need to limit foreign equity to no more than 50 per cent, if a business in this country is to play a full role of development.

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Electronics is the one industry where this country can make a big break-through as Japan did, domestically and in exports. Indeed we can do better, for we have a much bigger potential domestic market where we can regulate operations. India may have a low standard of living, but we are not a "poor country". As the Scientific Policy Resolution says: "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".

"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."

We shall talk later in this Conference of the project proposed by the Indian Space Research Organisation of the Department of Atomic Energy for a national satellite for communication purposes. This is one major task which can provide, as the Apollo Project to the moon did for the United States, a means for rallying engineers in a number of different directions to leap-frog from our state of technological and economic backwardness. It not only gives a most valuable input for national development through a powerful communication system reaching the remotest village or isolated community, but introduces us to the latest technology in space and electronics, offering employment to tens of thousands of engineers.

When we look at the problem of electronics, let us remember, the words of Shakespeare: "The fault, dear Brutus, lies not in our stars but in us that we are underlings."

Text of speech delivered by Dr.Vikram A.Sarabhai, Chairman, Atomic Energy Commission, at the Seminar on Pollution and Human Environment held in Trombay on August 26. 1970.

Dr. Ganguly, Ladies and Gentlemen:

I feel honoured to speak before you today. Two years ago, at the Scientific Advisory Committee of the United Nations, we were considering the question of the proposed Conference on Human Environment which is to be held under the auspices of the United Nations in 1972. At that time, the United Nations invited various nations to express their interests in this Conference on Human Environment. When we looked at the response which had been received, we noticed that what interest there was - there was quite a bit of it -was from the industrailly advanced nations. Developing nations, including India, had largely remained silent. When I enquired later on as to why India had not expressed any interest at all in this Conference, I discovered two things. First, that there was a widespread belief even amongst our own national policy makers that the problem of human environment was largely an affliction of the industrially developed societies, and that since India was still quite remote from this problem, we could tackle it in its own time, and secondly, there were more pressing problems to be attended to immediately.

There was perhaps another equally important factor in our approach in this regard - there was no national group or body which was concerned in this matter, which could take into account not only public opinion but also Government policy makers, and bring to their attention those aspects of the

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problem that there of immediate concern as well as those long range in character.

Even though I was myself an ignoramus in this particular field, it did not take me much time to recognise its importance. When I came back to India after the meeting, I formally raised this matter before the Committee on Science and Technology (CoST) set up by the Cabinet, of which I was a member. When I put this question to CoST- whether it was a relevant matter to India and whether we take it that India should do some thing about it, I was happy that my colleagues in CoST immediately responded very favourably to the proposition I was trying to make. CoST first asked me to set up some machinery on behalf of CoST by which one could get a sound basis especially for an understanding of the subject and for an on-going study of the subject - for influencing not only public opinion but also national policy makers. I was very happy when Dr. A.K. Ganguly responded to my invitation to take the role of bringing together various interests who had certainly been recognised in their own spheres, but lacked an organisation, platform or forum in which to discuss these matters. I am delighted that today we have taken the first and major step forward in bringing together the scientists in the field under the initiative of CoST and through the significant work of Dr. Ganguly and his colleagues.

I do hope that the beginning you are making to be continued with great vigour and the future generation of India

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would be thankful to this group meeting today.

I deem it a judicious decision that you have chosen Trombay as the first place to meet, for the simple reason that in matters like atomic energy and pollution, you do require to take extreme precautions, And it is only when this problem is faced in its starkest and most brutal from that man wakes up to do something about it. I think that in the papers you have before you, you will see the record of work that has been done by BARC at Trombay and at Tarapur. Much early thought and preparation have gone into real study of the ecological aspects of environmental pollution.

Gross pollution is something which we are all aware of. In my boyhood days in Ahmedabad, we used to observe the black smoke coming out of the factory chimneys and its dispersion in the countryside. When there appeared to be too much of it, there used to be some critical observations and sometimes engineers used to do something about it. This type of gross pollution another example is the stink that comes from the sewage which has not been treated properly is, I think, something that most people are aware of. Most of these types of gross pollution are dealt with in a pragmatic and practical way. Even the containment of radioactive wastes is a thing in which we need this pragmatic approach, while making containers which have the required integrity and which we hope will not break and nothing will happen to them for hundreds of years.

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I know that many of the papers that are going to be read today deal with problems of gross pollution. I would like to emphasise for your consideration here, the vital sphere of environmental pollution which deals, apart from this aspect of gross pollution which should be contained or controlled, with problems of biospheric and bioenergy balances. It seems to me that from the realisation which has grown for the last 2-3 decades, problems of ecological and energy balances between various living and non-living systems and the manner in which the ecology of the environment and the welfare of the human being are intimately connected are much better understood today. It is this inter-dependence which puts on the whole problem of environmental protection a new dimension which is both far reaching in character and inevitable in its impact.

I would like to emphasise three different aspects of this problem. I think we should recognise that many changes or modifications in the biosphere and Ocosphere are irreversible in character. This is the first aspect - that onee changes have occurred or have been induced, it is not possible to take corrective action later.

The second aspect is that catalytic agents or triggered phenomena which by themselves in terms of materials release or energy release are quite insignificant compared to the total energy in the same area, can produce changes which affect the whole. There are a vast number of examples one can give in this respect.

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The third aspect I would like to emphasise is the cumulative nature of many factors. Many changes that occur over a period of time are sometimes erroneously believed to create no significant impact or only a very slow impact on the environment. In a cumulative multiplicative process, it is in the final stages that the whole system gets changed most and sometimes becomes uncontrollable. It is precisely this aspect of change of the biosphere that we have to be very careful about. A typical example of such changes can be observed in the population explosion.

Some years ago when I was the Chairman of COSPAR, I had a most fascinating time with space experts. Some outstanding biologists, meteorologists, physicists and chemists were also with me. We were asked by COSPAR to visualise what would happen in the era of supersonic transport when there may be flying a number of machines and rockets that would release exhaust gases in the upper atmosphere in large quantities. What is likely to happen to our physical environment by such releases? It is well known that .4% of the total atmosphere which is carbon dioxide is responsible for absorbing *6%* of the total energy of the incident solar radiation. Over *a* period of years, by burning fossil fuel, the carbon dioxide content has increased by 15% It is this aspect of absorption of solar energy before reaching the earth which may effect changes in the land, water and air environment on earth. It would affect the heat balance of many other things. Somebody onee proposed

that it should be possible to put a payload of dust at the equator at a great height and this great belt of dust particles would make a major modification of temperatures and the heat balance between the equator and the poles. This is not a mere fantasy.

One of the most important aspects in which the Atomic Energy Commission is directly concerned is the power needs of the country. Many of you may be aware that apart from the other forms of pollution, thermal pollution has become a very important matter in the developed societies. When one produces power, one discharges heat into the environment. In many regions of the industrialised world, this has caused thermal pollution and has changed the energy balance in the area. It is in this region that new studies in electromotive gas (EGD) machines are of great interest. They are meant to provide means of producing power at reduced heat discharges. These are the sort of things which we must look into.

It has been estimated that the average American utilises the power equivalent of nearly 500 slaves. If all Indians had 500 slaves each, we would have a real problem in terms of energy consumption and attendant thermal releases! So, in our studies of the biosphere and ecosphere, apart from empirical and pragmatic solutions, We need - deeper understanding of their interdependence. I think it is here that the Health Physics Division, BARC and Dr. Ganguly and his grouo have laid the foundations of a very systematic study - even before the Tarapur

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plant came into operation. Many more such studies are obviously required before we understand the particular interdependence of man and his environment*

It is only recently that India has become aware of such interdependence. There is the water pollution bill before Parliament and legislation has been proposed by many States, particularly Maharashtra, to deal with water pollution control. I think these are important first steps in the right direction. There is also an air pollution study committee and consideration is now going on about regulatory mechanisms. I welcome these developments and would like to emphasise that the measures for regulatory enforcement are basically dependent on the understanding of the phenomena and it is here that this group of professionals - scientists and engineers - can contribute most effectively, by rallying their totality of understanding. A large number of observers have responded to our invitation and this has been a great source of satisfaction to us. I hope those who are observers here today will make significant contributions tomorrow. In the UN Conference in 1972, I hope we will be able to make original contributions on the manner in which developing societies are tackling the problems of pollution of the human environment.

There are at least two major matters which we have to face. The first one is the problem of DDT. Most of you are aware there is major concern expressed and legislation taken up to control the use of DDT in order that this may not build up

Into; a long range problem. What is going to be our policy recommendation - to spray or not to spray, and what is the alternative - these are some of the questions which we shall have to examine. Another even more far reaching problem is that of electric traction. At the time when privately owned automobiles are still just a few in number compared to the population of India, it is necessary to see whether our automobile industry should make large investments in the internal combustion engine or invest to develop and perfect the electric traction engine.

While innovating man must inevitably interfere with environmental systems; it is upto us the scientists to see the way by which man will reap both short term and long term benefits from these Innovations.

Text of Speech delivered by Dr.Vikram A.Sarabhai on his election as President of the Fourteenth General Conference of the International Atomic Energy Agency in Vienna on 22nd September 1970.

I wish to thank the General Conference for the great honour done to my country and to me by electing me to this high office.

Under the leadership of Jawaharlal Nehru, Dr.Homi Bhabha not only established the relevance of atomic energy to a developing nation but also demonstrated the role that scientists and engineers of such nations can play internationally in promoting the peaceful uses of atomic energy for the benefit of all. Homi Bhabha significantly contributed to the creation of this Agency and to the convening of the first United Nations Atoms for Peace Conference in Geneva of which he was President. That Conference was a landmark in the unique transformation of a technology developed for military uses to one destined to play a most important role in peacetime.

I am deeply conscious of the great trust and responsibility that the delegations at this Conference have reposed in me. I particularly appreciate the kind references made today.

In atomic energy, we stand at crossroads. This lends very special significance to the deliberations of this Conference and the continuing work currently undertaken by

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many other bodies connected with this Agency. It is our common obligation to ensure that we establish a base for the future recognising the inherent character of scientific and technological innovation which represents man's most profound urge for knowledge and self-advancement and must therefore be available to all in equal measure. It is our responsibility to take note of the compelling urgency for economic and social progress of all people and to take concrete measures in spite of ideological and political differences between nations, traditional hostilities and competition and the insecurity generated by these forces. This calls for wisdom and maturity of a high order, of trust as well as understanding, and above all of self-restraint. The importance of taking equitable decisions and adopting procedures strictly in conformity with the letter and spirit of the statutes of this Agency must constantly be kept before us.

A most positive development during the past year has been the work of the safeguards committee to prepare for new responsibilities which fall on this Agency from the non-proliferation treaty. There are already positive signs of an emerging rational approach concerning the manner in which safeguards should be applied. The request to the Director-general to examine the financial implications of the safeguards responsibility of the Agency in the future is extremely important since at the present time no one appears to have a clear idea of the magnitude of these responsibilities and

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the manner in which the Agency can maintain an appropriate balance between its positive promotional activities and the control functions to prevent misuse.

There is understandably today a deep concern about pollution of our environment. Delegations to this Conference are aware of the lengths to which efforts have been made in the past to safeguard against harmful pollution by the uses of atomic energy. Indeed the record so far has been excellent. However, it is timely that the Agency bring together specialists to review this problem in the very best traditions of scientific objectivity and propose measures to ensure that in the development of nuclear energy utmost caution will be exercised. I have no doubt that these activities will help to create informed public opinion essential for future growth.

A long term plan backed by appropriate commitment of funds, personnel and facilities for taking the benefits of atomic energy to the large number of developing nations is essential if the problems which are likely to be faced in the world in the next decade are to be effectively tackled. We should note that unless we adopt very special measures involving new norms of international collaboration and assistance, the gap between the atomically advanced nations and those not yet in this category, will rapidly widen as in other areas of development. Moreover, if the full benefits of atomic energy are not quickly harnessed for development, we shall be

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creating economic and social conditions far more dangerous to the security of the world than the clandestine diversion of fissile materials for military use, the prevention of which we are all anxious to ensure. It is my conviction that just as major hydroelectric and irrigation schemes related to common natural resources tie together the economic viability of nations and put a premium on coexistence overriding political differences, so can low cost nuclear energy centres provide the forces of social and political cohesion in all inhabited regions of this troubled world.

A study is currently being made by the United Nations of the benefits of space research and their applications to developing countries. A similar comprehensive overview for atomic energy is probably a prerequisite to future initiatives of this Agency.

I wish to express appreciation on behalf of all of us to the Director General and his staff for the untiring and dedicated services to the Agency.

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Bhabha Memorial Lecture of the Society of Nuclear Medicine, India (New Delhi, October 21, 1970).

THE MATRIX OF DEVELOPMENT

Nuclear Medicine in the Seventies by

Vikram A. Sarabhai Chairman,
Atomic Energy Commission

I am deeply touched by your asking me to deliver the first Bhabha Memorial Lecture instituted by the Society of Nuclear Medicine. This nation owes a great debt of gratitude to Homi Bhabha. I was privileged to have his friendship and association as a scientist for almost 30 years before he died, and I derived inspiration and support from what he was doing for Indian science and for the nation in a wider sphere. In paying homage to him today, I wish to dwell not. so much, on his many achievements in the field of Atomic Energy bat his style and the administrative practices which he evolved for innovative tasks. His philosophy was one of self-reliance and of self-respect, He was willing to stake his reputation for achieving the most difficult tasks, rather than take the easy way. He was a strong advocate for the creation of a new culture in Indian science and Indian engineering - in Indian life. He was not conscious of seniority or status and all through his live, we seen an adherence to excellence in work and method. If, indeed, there was a pace-setter in modern India, Bhabha was this pace-setter.

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Bhabha considered life in its totality, its serious aspects and its aesthetic aspects. He had great energy and an ability to go into details. Above all, he was a warm human being who had great trust in those who would apply themselves vith seriousness to work. And just as he was intolerant of stupidity, he was generous to those who completed a task they had undertaken.

He often talk of the imprint of the personality of a man on the organisation he has created. Surely, what we are referring to is the manner in which his assumptions concerning tasks and the motivations of people involved with them are translated into a management system.

Bhabha emphasised that in India, the first step in building institutions was the training and development of people. In starting a new institution Bhabha corisidered it important to build the organisation around people rather than to draw an organisation chart first and then fill in the vacancies.

He said that it is a fallacy to believe that "we are reasonably advanced in administration but backward in science and technology". He was aware that different tasks and institutions required different types of

administrative practices, and that the transfer of traditional administrative practices of government, either to industrial enterprises or research and development produced inefficiency and lack of morale. He recognised that the administration of scientific research and development is an even more subtle matter than the administration of industrial enterprises, and. that it could not be done on the basis of borrowed knowledge.

Bhabha introduced administrative practices in the Tata Institute of Fundamental Research and later in the Department of Atomic Energy, which were alien to established University and Government procedures. Scientists and engineers were paid according to their merit and maturity, rather than in terms of organisational position and status. Promotion did not imply handing over charge of one.task and going over to another. Positions were created whenever competent people were available for identified tasks. As with personnel functions, Bhabha established procedures, for procurement as well as for civil construction, in which major decisions were taken by the scientists concerned.

The emphasis was throughout on developing know-how indigenously and on growing people, able to tackle the

tasks which lay ahead. The generation of self-confidence and the ability to engineer and execute industrial projects without foreign technical assistance were major objectives. He observed and I quote :

> "The construction and operation of a number of steel plants had not automatically generated the ability to design and build new steel plants. Unless powerful scientific and engineering groups are established during the construction and operation of existing steel plants as a matter of deliberate policy, the dependence on foreign technical assistance will continue and the steel industry will not reach a stage of technical self-reliance. A similar situation exists in almost every other industry."

In order to draw a moral from Bhabha's work, Professor Kamala Chowdhry and I attempted some years ago a case study of the Atomic Energy Commission of India, as an organisation for developmental tasks. We observed that the early beginnings of any institution are crucial, and the 'culture' (or lack of it) brought by the first entrants plays a significant role in establishing norms, procedures and practices in the organisation. Their numbers should be large enough to achieve a critical size to permit positive interactions.

In professional groups of 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 is appropriately one of service and not of control. This requires a basic change in attitudes rather thai" a change in procedures and practices. Control is exercised through interaction with and judgment of peers.

There is a need for a constant interplay between the basic sciences, technology, industrial practice and management if economic progress is to result from the - activity undertaken. The wearing of several hats by the same person, as in the case of Bhabha and the mobility of personnel from one type of activity to another have undoubtedly provided the impetus for growth in the projects of the implement of Atomic Energy. It is my firm conviction that we would make a serious error if we were to regard the moral we have drawn as applicable only to special situations such as the development of atomic energy. In his last years, Bhabha as Chairman of the Government of India Committee on Organisation of Scientific Research, strove hard to point out the generality and, indeed the necessity, of applying the practices and organisational philosophy ho had evolved in the Atomic Energy Commission to other scientific departments of

Governmert. It is tragic that four years later this view has not been generally recognised. much less implemented.

When Bhabha died early in 1966, he left behind a precious legacy. It is my purpose today to explain where we stand in nuclear medicine and outline a profile for the future which we would do well to commit ourselves to. There are many experts in nuclear medicine here in the audience, but there are also many non-specialists, who would be curious about the distinguishing features which have made this one of the most rapidly expanding fields of modern medicine.

Until artificial radio activity was discovered by Rutherford in 1919, we were aware only of the high energy sub-atonic particles and wave radiation associated with cosmic rays and naturally occuring radio active substances.

Most elements that naturally occur are stable. In others words, the atoms of these elements exhibit chemical properties which do not change with time. However, when these elements are bombarded by high energy radiation, such as neutrons from an atomic reactor or the beam of *a* high energy accelerator such as a cyclotron, every now and then an interaction occurs with the nucleus of the target element which gets transformed into an isotope, which has

an atom of the same eheiaical element, but different mass, or an atom of a different element. These transformed nuclii are usually not stable and are called artificial radio nuclii. They emit other high energy radiations, just like naturally occurring radium does, but their activity of omitting such radiation decays with a very characteristic time period measured in terms of its half life. It is this property which is most
Valuable in the wide applications of radio nuclii for medical diagnosis. For instance, I^{131} used widely for diseases of the thyroid has a half life of 8 days and
GO
Tc- ^{99} (Technotium) has a half life of only 6.6 hours. Though short half lives present many speial problems in the manufacture and distribution of radio pharmaceuticals, the great merit in their use lies in their selective absorption in different organs of the body and relatively little radiation burden imposed by then on the general system. While their activity lasts they provide unique information through radiation that they continue to emit after absorption in a particular normal or deceased organ of the body. The detection of the emitted radiation by external instruments is due to their great power of penetration. To put this matter in the correct perspective, let us note that while the quanta of X-rays have energy several tens of thousand times greater than in visible light, the gamma rays and the sub-atomic particles

in radio activity have several million times the energy of visible light.

An analogy might make clear the manner in which radio Pharmaceuticals are used for diagnostic purposes, Suppose a child has been slapped. He would continue to cry for perhaps ten or fifteen minutes. During this period, anyone who is not hard of hearing would immediately be able to locate in a crowd not only the child, but also perhaps his parents who would be accompanying him. When the child recovers his normal composure, there will be no way of distinguishing him or his parents from the rest of the individuals in the crowd.

The therapeutic use of radio Pharmaceuticals is connected with the well-known effects of radiation, on biological systems. Cobalt 60 with a half life of 5.3 years and Cesium 137 with a half life of 30 years are used in teletherapy units. 99% of all in vivo nuclear medicine procedures use Iodine 131.

Some of the most important advances in nuclear medicine in recent years have been rendered possible through the availability of Technetium-99 m with its short half life. It is now considered almost an ideal radiopharmaceutical for a wide variety of applications. The very favourable nuclear characteristics of this isotope make it specially attractive for various
diagnostic procedures.

Te-99m is conveniently supplied, through generators or milking units which consist of columns of chromatographic alumina on which the parent molybdenum-99 (half-life 67 hours) is firmly absorbed; Tc-99m is milked out of the column, using dilute sodium chloride solution. The Tc-99m thus milked out can subsequently be converted into various chemical forms suitable for liver, spleen, lung, bone and placental scanning. The availability of such type of generators enables doctors located away from the production centres to use such short-lived isotopes in valuable diagnostic procedures.

For the production of Tc-99m generators based on chromatographic alumina, it is essential to have the starting material i.e. the parent molybdenum 99 with a specific activity exceeding one curie per gram. For the production of such high specific activity molybdenum 99 in substantial quantities it is essential to irradiate natural molybdenum at neutron flux exceeding 3×10^{14} neutrons per cm^2 per second. It is not practicable to prepare those generators from low specific activity molybdenum as the product Tc-99m is likely to be contaminated with excessively large quantities of molybdenum, alternatively Tc-99m can be made available in a pure form after separation from the parent, but the short half life restricts the availability of this product to institutions

which are readily serviced from the production Centre. A procedure has now been standardised at Trombay for the production of pure Tc-99m from low specific activity molybdenum 99 and routine production and supply of Tc-99m as a guaranteed radiopharmaceutical is expected to be taken up shortly.

Eventhough the first batch of indigenously produced radio isotope from the Apsara reactor was released for medical use in 1958, routine production of several radio-pharmaceuticals on a fairly large scale was taken up at Trombay towards the end of 1963 with the start up of the CIRUS reactor. At, present more than 50 different radio-pharmaceutical preparations are on the production list. Considering the range of products produced completely in India, we rank among the top five to six countries supplying radiopharmaceuticals in the world.

While significant progress has thus been made in the development and routine production of radiopharmaceuticals in this country, in the matter of their application in Nuclear Medicine, India has lagged way behind the advanced countries and is even well behind some other developing countries. While there are about 65 medical institutions currently using radiopharmaceuticals in India, excepting three or four centres, all others are confined to thyroid uptake studies using radioiodide. In the

United States of America about 40 million dollars worth of radiopharmaceuticals art; consumed annually. In Japan, this figure is over 2.5 million dollars. In India, radiopharmaceuticals valued at only 80,000 dollars (5 lakhs rupees) were used in 1969.

From a modest number of 400 consignments in 1961 we reached a figure of over 10,000 consignments per annum in 1968 with a doubling time of approximately 2 years' upto 1965. After this rapid progress there has been stagnation. This is not because the Nation's needs are fully met. Far from it. Let us for purposes of comparison examine the figures from other countries. Australia during 1967-68 carried out. 5.6 investigations with radio isotopes per 1000 of population, Denmark 7.1, Japan 1.7, New Zealand 2.4, Sweden 6.1 and United States in 1966 a figure of 9.2. The corresponding figure for India is only about 0.05 per 1000 of population. There are at present about 80 medical radioisotope users in the country and among then there are perhaps only 2 or 3 institutions which account for more than 80 per cent of the consignments of radioisotopes.

There is a possibility of drawing erroneous conclusions when we compare figures in India with those in industrially more developed nations enjoying a much higher standard of living. However, experience in Greater Bombay related to the Radiation Medical Centre

of the Bhabha Atomic Research Centre provides a good indication of what can be achieved at least in our metropolitan and urban areas. The number of investigations conducted per year per 1000 of population of Greater Bombay works out to 2, a figure comparable to Japan and Few Zealand. We should note that the Centre is not merely a well equipped clinic for nuclear medicine but undertakes training of doctors in various aspects of nuclear medicines and the Bombay University itself has recognised nuclear medicine as a speciality and has instituted a diploma in radiation medicine. A similar diploma for technicians has also been instituted.

Until recently little progress was made in this country in some of the most important areas of nuclear medicine such as scanning, primarily because of non-availability of adequate funds for scanners, ancillary electronic equipment and accessory facilities and infrastructure. The Electronics Corporation of India, a public sector enterprise of the Atomic Energy Commission is now marketing these. In the U.S.A. with a population of 200 million there were more than 6500 hospitals and licensed doctors using radiopharmaceuticals in 1969 with an average of 100 new nuclear medicine facilities being added each year. There were about 10,000 scanners and 300 scintillation cameras in use. In Japan with a population of 100 million, there are 3500 scanners. There are at present just

11 scanners in the whole of India and just one scantillation camera.

Taking all factors into consideration it is perhaps reasonable to aim by 1975 to provide a target of 2 investigations per thousand of urban population. This would involve approximately 100,000 investigations per year. Once the infra-structure is established a doubling time of two years is quite reasonable taking our past experience and that of other countries into consideration. On this basis we would need to provide for approximately 0.75 to one million investigations by 1980.

Following the style of the systems analyst let us examine what is involved in our being able to provide modern radiation medicine in, this country on the scale envisaged. As I have outlined in Table I we can identify, at least five major initiatives that would be needed.

First, we must ensure the availability of an adequate supply of radiopharmaceuticals at reasonable price. The starting up of our large power reactors during the next 3-4 years st. Ranapratap Sagar and at Kalpakkam would give us the ability to produce about 3 million curies of radio cobalt annually. We shall also have the Variable Energy Cyclotron at Calcutta. This 80 Mev accelerator is under construction. But apart from the bulk supply of isotopes we would need chemical processing facilities and

one such large unit is under construction at Trombay. At present the manufacture of radiophamiaceuticals is carried out on a very small scale at the Bhabha Atomic Research Centre and a large unit for dispensing and testing would be needed. The distribution of radio Pharmaceuticals calls for special arrangements for transportation by air-planes with minimum hold-ups in transit and special precautions to be undertaken for handling the consignments. This needs effective coordination with civil aviation in this country.

Second, we should augment the availability from local manufacture of modern instruments as well as create a distribution and servicing organisation to maintain them in good order.

Third, we need more programmes for the training of Doctors and Technicians. In providing them specialised institutions such as the Radiation Medical Centre of the Atomic Energy Commission would have a very important role to play. So also car. training be given at selected Medical College Hospitals. With about 80 medical users of radio-isotopes, we will have to have as many as 1500 persons both medical and para medical to be trained in the medical applications of radioisotops.

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Fourth, one would need the establishment of an adequate number of units for radiation medicine in public hospitals and private clinics. This could be achieved by establishing a number of small radioisotope laboratories which are supported by a few large centres. There are at present 95 medical College Hospitals in India concerned with undergraduate and post-graduate medical education distributed among the various States. This figure will increase to 105 by the end of IV Plan. Setting up of snail radioisotope laboratories in each of these Medical institutions would serve a large cross-section of at least the urban population and also provide an unique opportunity for training of the medical and para-medical personnel attached to these institutions. It is estimated that a small radioisotope laboratory can carry out about 5000 radioisotopic investigations per year and commissioning of 105 radioisotope laboratories, though a phased programme would, by 1980, ensure a substantial coverage. The small radioisotope laboratories in the various radical institutions proposed above, require to be supported by regional or zonal institutions which by their facilities and inter-disciplinary representation among the staff, would be in a position to provide such of those advanced techniques in diagnosis and treatment, which would not be possible at the peripheral radioisotope laboratories in the region, and also be

responsible for carrying out research in problems peculiar to the region. Such institutions will have a multiplier effect on the overall development. and progress of medicine at the national level. There would be need for an advisory service run by the Atomic Energy Commission to assist the setting up of these clinics and for special technical information which may be required.

Finally there would arise *a,* need for radiation protection of the workers engaged in the expanded programme of radiation medicine. We are already well established to undertake this through the Directorate of Radiation Protection of the Atomic Energy Commission.

With the availability of high activity radio Cobalt from our atomic power stations, we shall be able to augment in two years the supply of indigenous tele-therapy units to satisfy the large demand which exists today. India has currently only 45 teletherapy units against about 600 in Japan and about 1500 in the United States.

An important application of Cobalt 60 in the field of medicine is for the radiation sterilisation of medical products like sutures, disposable syringes and surgical dressings. A large facility for radiation sterilisation is now being planned with assistance from

the U.N.D.P. It is expected that by the end of 1972 or early 1973, a plant will be operating at Trombay and will serve to sterilise medical products manufactured in the Bombay area. The capacity of this plant will be progressively stepped up to cater to requirements upto a maximum of 1 million cubic feet per year. It is also proposed to set up 3 other large sterilisation plants in the plan period in other regions in the country, where market surveys reveal a demand for such sterilised products. These facilities will serve to upgrade the quality of medical products available in the country.

1 have discussed today many practical applications of radioisotopes. If India is to be amongst the advanced nations in the world in the field of radiation medicine, our effort will have to be supported by a very major programme of basic research. Radioisotopes have now made it possible, to understand living processes in dynamic terms. A quantative analysis of the intermediate steps operative in homeostates is possible with the help of this modern tool. Prior to the advent of radio isotopes, majority of the conventional diagnostic aids were either static bits of information in established diseases or were more in the nature of confirmation of a clinically suspected condition. The results of such investigations generally failed to provide a comprehensive picture of the processes leading

to the diseased state.

Advanced biological and medical research would receive a great stimulus from an active programme dealing not only with radiation medicine but all the five elements listed earlier by mo as the ingredients of development in this field. The success of any part of the programme depends on every other. Let us recognise the Matrix of Development and make a deep commitment to the task in the style of Homi Bhabha.

TABLE I

Radiation Medicine

1. Radiopharmaceuticals	Bulk supply of isotopes Reactors Imports R & D	Chemical processing Hot Labs R & D	Pharmaceutical Manufacture Subdivision Testing R & D	Distribution Special Transport Handling
2. Instrumentation	Manufacture R&D	Distribution Servicing		
3. Training	Doctors Technicians			
4. Clinics	Public Hospitals Private R&D	Advisory Service		
5. Radiation Protection	Badge Service R & D			

REMOTE SENSING IF THE SERVICE OF DEVELOPING COUNTRIES*

by

Vikram A. Sarabhai

1. INTRODUCTION

1.1. Space exploration has advanced along two major directions. The first is concerned with the outward exploration, which encompasses the efforts to reach out into the space, to investigate the physical nature of the solar system, of the interplanetary space, etc The other is concerned with the exploration inward This aspect of exploration is concerned with looking back towards the earth from space - the inverse of Astronomy. Remote Sensing belongs to this kind. In its broader definition, Remote Sensing represents the joint efforts of using modern sensors, data processing equipment, information theory, processing methodology, communication theory and devices, space and airborne vehicles, and large systems theory and practices, in coordination with the relevant earth sciences disciplines for the purpose of carrying out aerial or space surveys of the resources on the earth's surface or just below it. It is concerned with the direct application of everything connected with space technology for the betterment of man, particularly in the developing nations. Hence it is of great relevance to India.

1.2, Modern Remote Sensing devices include passive and active systems and employ different bands in the visible spectrum, in the near infra-red and the far infra-red as well as in the centimeter radio waves.

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* Presidential Address delivered at the Eighth Annual Meeting of the Indian Geophysical Union on 29th December 1970.

Fortunately the atmosphere is transparent for all these bands, when cloud free, and to some **even** when clouded. The reflectivity and emissivity of the terrestrial objects in the lithosphere, hydrosphere or biosphere, in the various bands of the electromagnetic speotrum are quantitatively registered by the sensing devices. Recordings in twenty bands, over a ten stage intensity scale, can provide ideally, 20 or nearly ten thousand billion different combination, or "finger prints" of terrestrial features.

2, PLATFORMS FOR REMOTE SENSING

2.1. The higher the elevation of the sensing platform the greater is the area viewed on the surface of the earth. A geosynchronous satellite platform at nearly 36,000 kilometers will continuously cover a third of the globe, although the resolution will be about 30 km x 30 km. With normal sun-synchronous satellite altitudes of 800 kilometers, the sensors can view a surface of area of about 160 km x 160 km at a time and can cover the whole earth in about seventeen days; the resolution area will be 150 m x 150 m. An aircraft flying at an altitude of 10 km can cover an area of 5000 sq. km. in a 3 hour sortie. The earth's surface area being 5 x 10^8 sq. km., it would require 100,000 sorties or 30 years for one aircraft to cover the globe. However, the resolution will be much better, almost 2 m x 2m. Thus with remote sensing techniques, it is possible to map large areas quickly, and monitor conditions that change with time. Data from space-craft will provide information that will add to the efficiency of aircraft and ground surveys. Data from aircraft will add to the efficiency of ground exploration.

3. INTERPRETATION OF DATA

3.1. Remote Sensing applied to agriculture, forestry, oceanography, etc. produces images and analogue data, whose deciphering and interpretation require special skills. When ground data are derived from

aerial images, it is also necessary to validate them through independent ground observations. The whole scheme is known as establishment of ground truths.

4. OCEANOGRAPHY

4.1. More than seventy percent of the earth is covered by the oceans. Hence any earth resource survey should include oceanic surveys. Unlike the static ground surface, the ocean surfaces are dynamic, subject to continuous change. Their expanse coupled with their dynamic nature, make a broad scale surveillance by conventional methods of ship-borne instrumentation practically impossible.

4.2. All the fresh water used by man in Agriculture and Industry is being recycled into fresh water through evaporation. The role played by the location of abnormally warm oceanic areas in causing the vagaries of the rainfall (including that of the Indian Monsoon) is gradually being realised by meteorologists. Thus, a survey of the oceans becomes essential for the forecasting of weather over land and sea, On behalf of the world Meteorological Organisation and the International Council of Scientific Unions, a group of meteorologists are now involved in a project known as Global Atmospheric Research Programme (GARP). They have realised that the Tropical Oceans play a large part in the generation of global weather systems. In order to investigate the details of this role, plans are afoot for conducting an experiment in the northern equatorial Atlantic in 1973. The planners have definitely stated that a geosynchronous and a couple of sun-synchronous satellites for surveying the oceanic area under investigation are essential requirements for the experiment.

4.3. For over a decade (since April 1960) weather satellites have been taking pictures of the cloud cover over the globe. Initially pictures were taken during sunlit hours only. Using infra-red sensors, pictures are taken now-a-days during night-time hours also. Besides cloud pictures,

sensors in different infra-red channels provide information on the temperatures of the surface observed by them - cloud tops, or ocean surface or land surface over clear areas. Very recently interferometer equip-

15 mu band of carbon dioxide and the 6 mu

ment installed in satellites monitoring the 15 band of water-vapour are providing information on the vortical distribution of the temperature and water-vapour in the atmosphere from surface to an altitude of 50 km, This satellite technique appears to be the only feasible method for obtaining the temperature and humidity structure over the oceans.

4.4. The Gemini Manned Spacecraft Missions, brought several colour photographs of the earth's surface taken during the flights. A vertical view of some coastal areas in Florida, showed shoal areas and underwater detail through colour tones. Sedimentation patterns over large lakes were clearly discernible. Several atolls 60 miles or less in diameter appeared in the central Pacific. Such ocean photographs have already been used to revise hydrographic charts.

4.5. Biological productivity of plankton and fish is perhaps the most important oceanic resources. In the years ahead this resource must be surveyed, monitored, conserved and wisely harvested. There is a significant correlation between ocean temperature and the location of large schools of fish so that information on the ocean temperature through infrared sensing would prove valuable to the fishing industry. Surface temperature measurements also help to identify locations of highest plankton concentration and therefore possibly locations of high population of fish.

4.6. The oceans absorb surplus carbon-dioxide in the atmosphere via phytoplankton which converts it into oxygen. Some scientists feel that the overload of industrially emitted carbon-dioxide might have already saturated the oceans capacity to effect this conversion. This also makes it necessary to monitor the areas of phytoplankton. Phytoplankton can be

killed or their vigour impaired through oil slicks or pollution films. With so many oil tankers, the risk of such films is large over the Arabian Sea. With many countries going in for underwater drilling operations for oil, the risk of oil slicks spreading over oceans is on the increase. It is desirable to monitor them. A. satellite sensor scanning in the near ultra-violet can detect oil slicks,

4.7 It is not known definitely whether schools of fish create thin films of fish oil. If so, the same technique of ultraviolet sensing will detect schools of fish swimming just below the surface.

4.8 Subtle gradations in ocean colour shown in the Gemini photographs correlated well with ocean flora. Hence this technique can be used to indicate areas of high food content where fish are more likely to be found.

As already mentioned ocean colour gradation in shallow waters can be used to up-date hydrographic charts. This is very necessary as the action of tides and currents are continuously changing the contours of the sea bottom, faster than the classical hydrographic surveys. From a space platform, small difference in colour can be detected through the use of multispectral photography or scanning imagery, using narrow band filters.

4.9 The areas and intensities of the sunglint provide data on the surface waves, which can be related to the surface wind. The state of the sea also produce differences in the sea colour when viewed vertically. Remote Sensing Techniques for these features installed in space-craft can provide information on the state of the sea. The state of the sea can be inferred more definitely using microwave radiations. However, the installation of such sensors in satellites are not contemplated in the near future. The information about the state of the sea can be used for appropriate re-routing of ships along routes offering less resistence to the ship's motion.

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(5) Waveheights upto 5m; (6) wind speeds to 15m/sec; (7) surface feature resolution of 1000m (with 1000 A° band widths).

The following table gives some of the applications of Space Technology to Oceanography.

Application	Type of Data	Inferences drawn from the data
Shipping	Wave height Surface temperature Surface temperature gradients Water Colour Temperature anomalies Water/ice interface	State of the Sea Currents Hazards like icebergs
Meteorology	Wave height Water colour Surface temperature Temperature anomalies	Winds Evaporation Cyclone development

Application	Type of data	Inferences drawn from the data
Coastal Geography	Land/water interface Colour tones and contrast	Shore line topography
	Water colour tone	Effluents from rivers and sediment deposits
	Water surface elevation	Sea levels and slopes
Marine Biology	Colour tones	Bioluminescence
	Colour tones	Plankton
	Colour tones	Schools of fish and algae
Sea Food	Sea surface temperature gradient	Upwelling
	Water temperature gradient Water colour	Currents and eddies
	Wave reflection and color tones	Bottom topography
	Ultraviolet or other vapour features	Oil slicks of petroleum origin or of fish origin

5. GEOLOGY AND MINERAL RESOURCES

5.1. It is well known that the primary non-human inputs into a nations economy are the mineral resources, and the economic growth of a nation depends upon the discovery and the effective use of those resources. The geological Surveys of the various nations have been entrusted with the job of discovering and mapping these mineral resources. In the past, the field geologist studied and mastered a small area which he projected into a broad, regional picture to which others contributed. Large-scale geologic maps were the laborious product of years of surface exploration. Now, in addition to aerial photography, geologists will have available the big,

synoptic view offered by remote sensing. These systematic space pictures will offer geologists a broad, integrating panorama from which they can select observables of interest for close-up looks by aircraft or ground parties.

5.2. Known relationships exist between concentrations of mineral and fuel resources and particular geologic features. Petroleum and metallic mineral deposits, for example, are frequently found near structural features such as folds or faults. In a space photograph, part of an entire mountain range could consist of a series of folded rocks, and in the series of folds might lie an **anticline** or dome which could yield oil. Aerial photographs have been used to identify such features, but pictures from orbital altitudes have proven to be superior for viewing the larger linear geologic features. A new fault system even in Southern California was first discovered in space photographs. Geologic fractures and faults are even more obvious in radar images than in visual pictures. Radar also penetrates clouds and haze, and can be used during night time. Although radars will not be carried aboard ERTS A and B, they are planned for later flights.

5.3. Satellite observations may be useful to geologists in other ways. Some mineral deposits yield heat through oxidation and may be detected by infrared sensors Repetitive satellite observations of the melting patterns of snow may also point to such deposits. Infrared imaging also indicates temperature differences at or near the earth's surface. These differences may indicate possible sources of geothermal power and volcanic activity. Repetitive observations in the visible and infra-red regions may disclose crustal movements and thermal gradients which could provide timely data for predicting natural disasters such as earthquakes, volcanic eruptions, and landslides.

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5.4. An example of the manner in which a developing country has made use of this technique is provided. by Brazil which has an active remote sensing programme in cooperation with NASA. In the first phase they trained 14 scientists and engineers in U.S.A. In the second phase using these trained personnel 40 Brazilians were trained. In the third phase Airplane flights were conducted over known areas of Brazil, using instrumented Aircraft loaned by NASA. The data were analysed jointly.

5.5. Their initial test site for geology was chosen to be a well-known area - the "Quadrilatero Ferrifero". This area had been surveyed for 16 years with conventional methods. By using the sensors on Aircraft they were able to produce a geological map which matched the existing one made with so many years of work. By using signatures calibrated with known features of the site, they have been able to double the surveyed area of the "Quadrilatero Ferrifero". In this additional area they have signatures indicating a huge deposit of itabirits (a quartzite containing micaceous hematite). This discovery is presently being verified. Another result was obtained from almost constant warm-spots indicated in infra-red photography. These spots corresponded to "Canga" (Iron ore) deposits. Apparently, since the thermal conductivity of the "Canga" is higher than its surroundings, the internal heat of the lithos-phere is conducted to the surface by the mentioned deposits showing up very clearly in the infra-red photos.

5.6. The following table summarises the applications of remote sensing in this field.

Application	Type of data collected	Use of data thus collected
Detection of Petroleum & other minerals	Coloured, black-and-white and infra-red photographs Magaetic field strengths Electrical conductivity measurements	Rock formations Earth folds, Drainage patterns Out crops, Location of magnetised ores, Location of conducting minerals

Application	Type of data collected	Use of data thus collected
Prediction of Volcanic Action	Infra-red temperature data Colour photographs	Anomalies of surface temperature Rock identification Spatial patterns
Prediction of Earthquakes	Infra-red temperature	Linear miorotemperature anomalies Time variation of slopes

6. HYDROLOGY

6.1. Fresh water is an extremely important terrestrial resource which requires proper management. The basic principle in water management and utilisation is to intercept the water when it is still fresh and to utilise it for human benefit, before it returns to the atmosphere as water vapour or to the ocean as contaminated water. The atmosphere contains about ten millionths of the total water, and all fresh water returns to the earth after staying in the atmosphere for a brief period, on the average, 12 days. In other words, the atmospheric water vapour is replaced about thirty times a year. However, its passage to and its precipitation on the land are extremely variable in amount and distribution.

6.2. Hydrological data are collected through raingauge stations, snowgauge stations, stream-gauging stations, snow-depth stations, water quality stations and ground water observation wells, evaporimeter stations, etc. Such a collection of data demands considerable time, funds and technical skill. Hydrology is a natural science very highly dependent on current data; old data are of value only for probability studies.

6.3. Water management activities include the mapping of water, studying its properties, predicting its behaviour, impounding it, diverting it, and using it to serve industrial and agricultural needs and to create electric energy.

6.4. Thus perishable hydrological data are to be collected expeditiously over a wide area if the performance of water management functions are to be satisfactory. Space technology using remote sensing and communication satellites appear to provide a satisfactory solution for the data collection problem. They can provide large scale, repetitive imagery of water systems significantly supplementing data taken at individual points. In addition, automatic sensors collecting data at individual points can transmit the measurement to a satellite, which can rapidly dump the data to a hydrological centre. Such an operational system has a feasibility of providing global, synoptic, repetitive real time coverage of the major aspects of the Hydrological Cycle.

6.5. A few examples of what can be done with such system are the following:

The available water in an entire river basin or lake system can be monitored repetitively. Repeated observations in the visual, infra-red, and microwave regions of the spectrum can be made of snow, glaciers, ice accumulations and melting patterns. These changes can be monitored during the seasons of the year over areas too large to survey by conventional means. More accurate predictions of the run off can be made. These forecasts, in turn, will enable hydrolo-gists to issue better flood warnings and to regulate efficiently the impounding and release of water in reservoirs. Management of programmes of flood control, irrigation and power production, as well as water for urban and industrial consumption can be wisely done.

In addition to reporting water inventories, remote sensing may help to reduce water losses. Underground fresh water is being lost to the sea. Aerial infrared detectors flown over the coast of Hawaii showed nearly 250 underground springs discharging cool fresh

ground water into the comparatively warm ocean. Such pictures may guide water prospectors to most likely drilling points. The same thermal principle can be used to locate areas where cool underground brackish water intrudes into the warmer rivers. The location of such zones can help in the protection of municipal water supplies taking off from the rivers.

Other water losses are caused by evaporation and the transpiration of water wasting weeds. These weeds have long tap roots, and the evapctranspiration by such weeds tend to lower the water table. Aircraft and satellites can locate and map areas infested with such weeds.

All these can lead to significant economic benefits to any nation availing itself of the appropriate space techniques.

7. GEOGRAPHY AND CARTOGRAPHY

7.1. Any plan for national development requires current accurate maps. Geographers are concerned with the location, arrangement and association of the earth features like rivers, mountain ranges, sea coasts, and of man made features like roads, townships, artificial lakes, etc. Maps form the frame work on which these features are marked. Maps also define the location of the various mineral resources. Normally such maps are prepared through ground triangulation surveys involving considerable time and effort and therefore funds also. Cartographers are continuously on the game of resurvey and preparing maps, and yet 70% of all the small scale maps of world are out-of-date and the remainder inadequate.

7.2. The best current method of obtaining accurate small scale maps of large areas appears to be aerial photography - an example of classical remote sensing. The compilation of small scale maps is a slow laborious process, even when aerial photography is employed. At least half-a-million such photographs would be required to make a satisfactory photo-mosaic of a country of the size of India, Preparing such a mosaic will be time

consuming and costly. From a satellite altitude, such a panorama of India would hardly require 200 pictures, which could be assembled in a few weeks time. In just one pass, the Gemini Astronauts photographed almost 80 percent of Peru in a total time of only three minutes. In the mosaic, thus obtained, one could see the gross patterns of land use, distribution of snow, the levels of the lake, geological forms of significance - in fact this contained more information than any available map of the region.

7.3. Since the sunlight angle changes during an aircraft flight, aerial photomosaics display variations in shadow patterns and texture, complicating their interpretation. Placed in an appropriate sun-synchronous orbit, a satellite is capable of producing pictures of the earth under virtually constant lighting conditions. In a sun-synchronous orbit, the satellite crosses the equator or any parallel of latitude at the same time each pass. Since the orbit plane of the satellite always maintains the same, fixed angle with respect to rays of sunlight, the illumination of ground features is consistent. Shadows in each adjacent satellites swath always point in the same direction. Images of large areas composed of pictures taken during many passes will display the same constant illumination. Satellite pictures are also geometrically superior to aircraft photographs of large areas because of the straight down view. The distortions caused by oblique cameras angles are eliminated, These features make possible automatic processing and interpretation techniques that are difficult or impossible to utilize working with aerial observation

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7.4. New maps made by satellite and supplementing existing specialised maps will be of great value to all of the geographical disciplines. Demographers will have new, updated imagery to use in assessing changing patterns of population and migration. Land use planners can see the actual patterns of land use all across the country. They can also see seasonal changes in these patterns. Urban geographers and city planners will have a continuous record of changing urban patterns. Regional planners, transportation planners, and cultural geographers will also strengthen their analyses with this new information.

8 AGRICULTURE

8.1 In any country, especially in a developing one, agriculture constitutes a large fraction of the gross-national product. In India it is almost 50%. Therefore, national benefits from an application of operational remote sensing techniques to agriculture can be large and appealing;

8.2. Repetitive aerial surveys during the vegetative growth and harvest times of a crop can provide reliable inventories of the size of the harvest. These techniques have been used for grape crops. Remote Sensing from orbiting satellites promises to extend such predictive techniques to very large areas and many crops like rice, wheat, maize etc. When photographs are taken in colour, tone and texture differences are revealed, which can be used for identifying and distinguishing various species and varieties of plant life.

8.3. Use of multispectral (including infra-red) imagery is expected to be of great help in the identification of crops and timber species, in the analysis of crop vigour, in the early detection of crop disease and other forms of crop stress due to deficient water supply,

Diseased or stressed plants reflect or emit electromagnetic radiations in the visible and infrared differently from healthy and vigorous plants. Large scale results of extensive irrigation practices and fertilisers can be more easily carried out through remote sensing than through spot checks carried out from the ground. Rapid inventories of livestock can be made with remote infra-red sensors. The utility of repetitive observations of large agricultural areas over short period of the order of one month cannot be overemphasised. Remote sensing is perhaps the only technique capable of achieving this with any degree of reliability.

8.4 The following table summarises the application of remote sensing to Agriculture/Forestry

Application	Kind of data, required	Use of the data thus acquired
Agriculture Forestry	Colour photographs in infrared and multispectral imagery	Disease damage. Insect Damage Infestation Patterns
	Colour photographs and multispectral imagery	Crop type and density Livestock census Expected yield of crops
	Photographs with different colour filters	Soil moisture Irrigation requirements Soil types

9. EXISTING EXPERIMENTS

9.1 India has successfully carried out a small remote sensing project on the early detection of the coconut blight disease.

9.2. It is well known that the Wilt (root) disease is the most important disease of coconut in the Travancore-Cochin area of Kerala. It affects about a lakh of acres of plantation and is estimated to

cause an annual loss of about 10 million rupees. Hence any method of detecting the disease early is of great economic value to Kerala. Remote sensing from aircraft appears to be a method for early detection of coconut wilt.

9.3 After hearing a lecture on "Remote Sensing", the Director, Indian Agricultural Research Institute, New Delhi, envinced an interest on the problem of detecting coconut wilt through Remote Sensing, ISRO communicated this interest to NASA, who arranged for a. preliminary examination of the problem by agricultural specialists at the University of California at the Davies Campus and the Berkeley Campus who felt that it should be possible to locate the diseased trees through "Remote Sensing", at an early phase of the disease.

9.4 On ISRO's request, NASA arranged to send one Scientist in February-March 1970, to help us take the necessary photographs. He brought with him a 70 mm Hasselblad Camera, another 70 mm camera and the necessary films.

9.5 Coconut plantations over a few areas in Kerala were taken. ISRO's Helicopter at Thumba was made use of. The photographs were taken from heights of about 1000 ft., using Kodak Aerofilms and also black-and-white films using different colour filters. A total of four hundred 70 mm pictures (coloured and black-and-white) were taken over a period of five days. Most of the photographs showed fine detail.

9.6 The directors and staff of the coconut research stations in South India extended their sincere cooperation. Areas containing infected and healthy trees were marked out by flag so that the aircraft could recognise the areas to be photographed. A Scientist from the Atomic Minerals Division of the Department of Atomic Energy,

experienced in aerial photography, *was* also in the aircraft during the survey flights.

9.7 Scientists of the Indian Agricultural Research Institute (IARI) were entrusted with the task of analysing the photographs. The case histories of the tree clusters in the Kayangulam Coconut Research Institute in relation to the Wilt (root) disease are available at Kayamgulam. The Scientists there have done considerable work on the causes, symptoms and effects of this disease.

9.8 A scientific report is under preparation by the IARI and is awaited.

A first analysis of the pictures have shown:

a) That the crowns of healthy coconut trees appear red in the infra-red false colour films

b) That the Jack trees appear red, but brighter than healthy coconut crowns in the same film

c) That the cashew trees appear pink in the same film

d) That some trees apparently looking healthy, but which have recorded a weaker infra-red reflectance on the film, were found to be infected by the virus. This was revealed by the presence of the virus in the juice of the leaves on examination by an electron microscope.

The last result confirmed our Anticipation that the disease could be detected by the new technique even before visual symptoms appeared.

10. IMPLEMENTING AN EARTH RESOURCES REMOTE SENSING PROGRAMME

10.1 It is suggested that developing nations who do not have plans of using Space technology for the survey of their natural resources

may seriously consider the advantages of evolving such national plans. The development of the skills and expertise necessary for earth resources surveys through remote sensing techniques can be accomplished through a phased programme. During the first phase, about a dozen scientific and technical personnel can be trained at universities and scientific departments of a country like USA., where those techniques are fairly well developed. If scientifically mature persons ere selected, this training period need be only about a year. If necessary, the United Nations Development Fund should provide financial assistance for the travel and living expenses and the cost of training.

10.2 In the second phase these trained personnel returning to their home country will train about forty or fifty scientists and technicians within the country. During this phase, it will be necessary to have laboratory and field equipment including instrumented aircraft. Remote sensing techniques reveal details of surface topography and of other features. Consequently, there can be considerable hesitancy on the part of a developing nation to collaborate with a foreign nation in carrying out earth resource surveys particularly when economic factors and lack of specialised hardware and technical know-how compel the use of foreign aircraft and crew. This difficulty can be overcome if an international agency carries out the training and initial operational surveys on behalf of such nations, with nationals in full charge of the acquisition and analysis of data.

10.3 For implementing programmes of this type, each country should have a national coordinating agency set up at the very beginning of the programme. This agency should appoint a full time manager for the purpose and either appoint about forty scientific personnel for a

period of two years or second them from other departments for the same period for full time work in the programme.

10.4 The Indian Space Research Organisation (ISRO) has already taken steps to have an infra-red (l2mu) scanner constructed in France in Prof. Morel's Laboratory. One Indian Scientist and an Engineer are in Paris engaged in the construction. This instrument, when ready, will be used for thermal mapping of oceans and land areas from an Air-craft platform.

11. ONE WORLD

11.1 There are currently discussions about the sensitivity of individual nations arising from apprehension about the consequences of a satellite remote sensing programme. It is our view that International Agencies and individual nations should realise that space technology has come to stay, that the world is shrinking under its impact, and that national boundaries cease to be recognised by high altitude satellites. These have become facts of life. Modern space age will gradually erase national boundaries in social, economic and cultural matters. This is already occuring in Europe and we may expect it to occur in other continents. Global Earth Resources Survey Programmes, will hopefully help mankind realise that this is a one world and that its resources are to be used wisely for the benefit of all mankind.

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MANAGEMENT IN THE CHANGING SOCIAL ENVIRONMENT

by

Vikram A. Sarabhai
Chairman, Atomic Energy Commission

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A B S T R A C T

1. I suggest we recognise that a qualitative, and not merely a quantitative, change is occurring in our environment.

1.1. Change related to human innovation often proceeds in geometrical progression, but since the surface of the globe and its natural resources remain constant - and the main centres of habitation change only slowly - its impact is often sudden. We have the analogy of an infection which multiplies in the human system at a constant rate over a two week period of incubation but it is only during the last two to three days that the symptoms of the disease suddenly strike like an avalanche, as the disease takes hold of the whole body. Another dramatic demonstration is seen on highways when the speed of traffic is measured in relation to the density of cars. Above a certain density, the speed precipitously slows down and a qualitatively new situation develops on the highway. Two examples illustrative of qualitative change of decision making required in civic affairs to deal with quantitative expansion at a constant rate but at two phases of urban development are given below,

1.1.1. For a five per cent annual increase of population, a small town of 10,000 inhabitants can meet the increased requirements of water for domestic consumption by deciding to dig a tube well every few years. The project itself can be completed in a few weeks through executive action wholly within the jurisdiction of the municipality. On the other hand, in a large city of five million population with the same growth rate, there

Keynote Address to the National Management Convention, New Delhi, Feb. 12-14, 1971.

would be need to augment the water supply through schemes capable of delivering 50 or 100 million gallons per day involving completely different technologies, scale of operations, time for advance planning and gestation and need for coordination with diverse agencies, national as well as international.

1.1.2. Twenty to fifty pupils can be taught by a single teacher in a single class room. Therefore, if in a small village, 10 additional students have annually to be provided for, they would probably cram into existing schools and the local authorities would hardly be conscious of the need for a continuous long range programme for training new teachers and for building new class rooms. The problem in Calcutta and Bombay is of course totally different and if the training of primary and secondary teachers is the responsibility of the State government, schooling cannot be adequately provided through decision making exclusively by the Corporation and within the time constant applicable to a small town.

1.2. Amongst the factors producing a qualitative change of our environment, we should particularly note the following: 1.2.1. Urbanisation.

1.2.2. Significant change of the distribution in the population of those below 20 years, in the middle age group and above 60.

1.2.3. Change of mobility and domain of interaction of human beings. The distances travelled per hour by a person who has to walk; a person who can travel by car, bus or rail; and one who can travel by a jet plane are approximately in the ratio 3: 30: 600. Since the domain of interaction depends on the square of these distances, we have a hundred fold change the moment road or rail transportation is provided and a further four hundred fold change the moment jet air travel is realised. Many areas of our country, such as Kashmir, Assam and the States in the North Eastern

region are experiencing in a short period of 10 or 20 years a two thousand fold increase of mobility.

1.2.4. Access through telecommunications. A speaker can in person be seen and heard by an audience of about 10,000 at a time. Using television and global broad band satellite communications, there is upto a ten thousand fold increased capability.

1.2.5. Electrical energy generation involves dissipation of more than 60 per cent as waste. Thermal and chemical pollution significantly alters the quality of the biosphere.

1.2.6 National sovereignty has been eroded through over flights of space craft and surveillance from satellites.

1.2.7 New constraints on the exercise of force have arisen through a stability which is based on deterrence rather than conquest or punishment through military action.

1.2.8. Two entirely new regimes, namely outer space and the ocean floor, are now accessible for economic exploitation and measures which affect security.

2. A qualitative change in the environment of the type indicated earlier, affects the process of decision making by managers. "Experience" is less relevant than "knowledge" and the "ability to learn and to innovate". One can cite a number of examples in diverse fields where the carry over of experience from an earlier environment into a new one which is qualitatively different poses great danger to our society.

3. Rapid rate of innovation and the social implications of technological developments are of great consequence to the changing environment and to decision making by managers.

3.1 Computers.

During the last fifteen years, calculation speeds have multiplied by 10 every five years. The size of the calculating units

have been divided by 10 and the cost of a calculating operation has been divided by 20 or 30. The current tendency of increasing speed of computers will probably be maintained for the next ten years, with speeds 100 times higher, using low temperature techniques. The development of operating systems is getting even more complex and costly. Since the reliability is far from complete, software failures are difficult to detect and their cost is high. The proportional cost of software in the price of computers increases continuously. A projection of the likely developments by 1990 made by the French College of Advanced Techniques and Territorial Development indicates:

3.1.1. The classical methods of data input (punched cards, punched tapes, magnetic tape linked to a typewriter) will have practically disappeared.

3.1.2. The principal means of access will be sensors of all types, conversational terminals, and optical methods.

At the present time, a distinction is being made between the method of data storage in which data is stored for future use (or for security) and is not accessible to the computer without human intervention, and the method of memory storage, in which data may be obtained (or modified) by the computer, at any time.

It is possible that these two methods will tend to merge gradually into each other. The magnetic tapes, which play the main part in information storage would thus be partly replaced by high-capacity memories with easy access. Substantial progress is expected in this field. The first laser memories are scheduled for 1971. Their capacity would be of the order of 10^{12} bits. Memories of 10^{15} bits with access times of the order of one thousandth of a second, costing about Rs1.5 crores are expected before 1980.

These memories will represent a massive revolution in the field of information processing and decision making. A memory of 10^{15} bits, for instance, allows for the establishment of files for all the inhabitants of the planet, comprising 10,000 characters for every single person.

3.2. Satellite communications. They provide low cost broad-band capability including diffusion of television through slightly augmented television receivers and rebroadcast via conventional transmitters for concentrations of population. Such a system, as is to be experimentally tested in 1974 by the Indian Space Research Organisation in collaboration with NASA of the United States, would provide a dramatic transformation in the capabilities for education and Instruction and for entertainment in isolated rural communities. By not imposing an economic penalty on service to isolated communities, a qualitative change of great social implications can occur.

We recognise that television can be a most important tool for development. In this context, its impact is at least as relevant, if not more so, to the isolated rural communities where the bulk of our population resides as it is to the urban population already subject to ether major influences of modernisation.

National T.V. programmes accessible through community receivers to all our clusters of population, urban as well as rural, permitting shared audio-visual experiences, can be a most important factor for national integration,

By providing entertainment and instruction of a high standard, T.V. can produce a qualitative improvement in the richness of rural life and thereby reduce the overwhelming attraction of migration to cities and metropolitan areas.

The progress of satellite communication technology during the past decade has been so dramatic that through increase of the power of the

down coming signal, the cost of an earth station is capable of being reduced 10 to 50 fold. The economic obsolescence of hardware based on systems costs occurs in a time span shorter than the mean life before failure of the spacecraft which has been put up.

One of the most dramatic aspects of satellite communications compared to conventional communications based on a linear system is multiple access capability. For instance, supposing near Madurai a major project is under construction and it has the need to talk only three or four times a day with Durgapur. In the conventional system, this would tie up on a demand basis the entire land line communications chain from Madurai to Durgapur via Madras and Calcutta, making the land line unusable to the intermediate points. Through a satellite, the terminal points at Durgapur and Madurai can be connected without blocking intermediate land lines. The implications of satellite communications for agencies responsible for health, family planning, education, agriculture, the defence services, the Ministry of Home Affairs responsible for security, Railways, Civil Aviation, Meteorology, marine navigation, the news agencies and access to large computer facilities and data handling systems, would bring about a qualitative difference in the whole nature of our operations in many diverse fields.

Management information systems and data banks for decision making would become possible and within the reach of not only large banks, airlines and hotel reservation systems, but also of smaller business units when a modern satellite telecommunication system as well as regional computer centres are available.

3.3. Nuclear Energy. Economic progress is crucially dependent on the availability of energy for industry as well as for agriculture. In the past, rich settlements grew where these were available either in their

own territories or by conquering others. In any case, low cost energy resources were tied to specific locations. Nuclear power requiring the transportation annually of no more than a few tens of tons of fuel has transformed the position and with low cost energy it can also provide desalted water, another essential need of the environment for growth in regions where economic development and human settlements were impractical.

3.4. Fertility control and genetic engineering. These are two fields in which developments are having a profound influence on our social institutions. The delinking of sex from the rearing of a family has provided a new freedom to the individual just as progress in computer sciences, satellite communications and nuclear energy have created a new freedom for collective human activity in regions separated from the main centres of population. If imaginatively understood, we have available now technological solutions that can reverse the strong attractive forces which produce urbanisation and ultimately give rise to a continuous urban sprawl extending over the inhabited regions of the earth.

4. With qualitative change in our environment and the fast rate of innovation, obsolescence of hardware any of people is great. The important ingredient for satisfactorily meeting the challenge of the changing environment is not experience, but an ability to learn. The most dramatic breakdown of our social institutions is reflected in the alienation of the young, Certainly a very major role has been obsolescence in education, where there is a gap of at least two generations. Those who learn today are receiving information and knowledge from those who completed their own learning a generation earlier, on curricula and methods moulded by others who preceded them by at least another generation. This truly is a most untenable position. It is not surprising that the crisis in education has affected all nations of the world rich and poor, developed and those which are still developing.

5. In an environment which is qualitatively transforming rapidly on a global basis we require

5.1. Long range projection of the environmental and social needs and action now for building the infrastructure on which solutions' of tomorrow would rest. The currently accepted time frame of five years, needs to be extended to at -least twenty years at the national level and to about 10 years in all enterprises.

5.2. Solutions which provide increasing interdependence between social and political organisations, cooperation, as well as a recognition of ecological principles.

5.3. Examination of new solutions for old problems. This involves evaluation of new innovations in technology and techniques with recognition of the implications of the man-machine interface.

5.4. Multi-disciplinary effort and recognition of multivalence of individuals and institutions.

5.5. Solutions which minimise hierarchical levels and provide autonomy of decision making at the level of sub-systems, in spite of the monolithic nature of many technological systems.

5.6. And most important of all, a culture which looks upon education not only as an experience to be consciously undertaken in the preparatory stages of childhood and adult life but as an activity to be systematically followed throughout the active career. There is generally no tradition of this type in public or private sector organisations. There is also inadequacy, at the present time, of formal programmes to cater to this need.

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THE GREEN REVOLUTION

by Vikram Sarabhai

I would like to give an account of what the Green Revolution means to India. But before 1 do so, and give you some figures and facts, it is perhaps well to understand the local situation under which this is occurring. As everyone knows, India's population now exceeds 550 million. The primary occupation and source of income for a major portion of the population is, of course, agriculture. Unirrigated farms constitute nearly 80 per cent of the total crop area of 138 million hectares. Most parts of India receive rain during the monsoon season, which extends for about three months, from July to September. Of the 138 million hectares which are under agriculture, only about 41 million hectares have an annual rainfall of 1100 millimeters and above, and about 49 million hectares receive a rainfall ranging from 750 to 1100 millimeters. Only 20 per cent of all farms resort to multiple cropping.

With growth of population on the One hand and stagnation of agricultural production on the other, the situation had become so serious during the late fifties and early sixties that India had to resort to very large scale importation of food, mostly with foreign assistance. But a remarkable change occurred in the mid-sixties. During the 1951-65 period, wheat from Mexico and rice from Taiwan as well as the Philippines were imported into India for breeding experiments, to see whether these new varieties would take in the Indian soil and produce

Talk delivered at the Plenary Symposium at the Pugwash Conference held in Sinaia, in August 1971.

the remarkable results they had already demonstrated. Side by side with the importation of these new strains from Mexico. Taiwan, and the Philippines, Indian agricultural research institutes embarked on an intensive plan to develop new strains for maize, wheat and rice. By 1965, these institutions and developmental agencies were ready to embark on a programme for wide propagation of the new varieties.

One of the first things that was noticed was that the type of grain and the colour of the wheat which had been brought from Mexico, and the quality of the grain of the new rice, were not similar to what the local population had been used to, and the preparations that were produced with many of these were automatically identified as inferior in quality. Hence, even though the productivity of these new imported varieties was good, the lack of acceptability by the population created a problem for their widespread adoption. Fortunately, the Agricultural Research Institutes in India succeeded during the period 1965-67 in genetically building into the imported varieties the desirable characteristics which the local population required. At the end of 1967, a wide variety of improved varieties, which conformed in flavour, celour, and taste to the ones that the people were used to, were in fact available. At that point of tine, about 1966-67, the lid was therefore taken off the rapid dissemination of the new technology in agriculture.

The first result of the application of these new varieties (and most of these had to be raised in the irrigated areas) was that yields were doubled; and as soon as yields were doubled and the short-ripening varieties were available, multiple cropping became very much more extensive than it had

been before. Production of food groins rose from a trend value of around 85 million tone to 108 million tonnes in a period of about 5 years. And the result of this has been so dramatic that, this year in fact, instead of having a net deficit of food, there is a not surplus. There is already a now problem that people had not fully visualised, the problem of storage of food grains.

The current five-year plan, which is now at the half-way point, provides for on increase of groin production from 98 million tonnes to 129 million tonnes. Of the planned increase of 31 million tonnes, at least 21 million tonnes are likely to be produced by the use of the new varieties. With the existing pressure on land, the big increases that are taking place are in fact duo to those new varieties. This is having, of course, a tremendous impact on employment in the countryside. Of the rural households in India, 52 per cent are small holders and about 24 per cent are agricultural labourers. In the areas where the high-yielding varieties have been sown, the employment has almost doubled. In fact, it is estimated that today, at the end of about four or five years of intensive work on these new varieties, something like 325 million labour days of additional employment have been created.

What about incomes? One of the most important aspects of the Green Revolution has been that it has reduced the relative disparities between largo and small land-holders in irrigated areas. In the past, only largo holdings used to bo able to fetch a viable form income. with multiple cropping and with those new varieties, even the small holders are now having a profitable agricultural income. I might quote an example from my personal experiences I have a domestic servant who, every

morning when I get up at about 5:30 or 6 o'clock and go to my study, brings me tea. He came the other day and said: "You know, I have been working for you for the last twelve years. I don't really know why I am working for you". I said, "Well, what's the matter?" He said that he had a small farm of about four acres and, about three years ago, through a loan he had taken from me, he had made a well, installed a diesel engine, and was now using the new varieties of seeds. He said that the income from his farm was several times greater than the income that he got as a salary earner in my home. What is more, he said that in his community it was improper for his wife, who was living there, to do the farmwork by herself. So he had to engage a neighbouring fanner to do this. That farmer's remuneration was such that it was taking all the cream out of his own farm holding. I said: "Then why do you serve me?". He said: "It is only because every time I am really in need, you give me a loan". This illuminates very well what the Green Revolution is doing to the people.

The disparity, therefore, in the farm earnings of large and small holdings has definitely gone down, very much as a result of the new varieties. But another serious problem is that this has increased the disparity of the earnings of the farmers in relation to the agricultural labourers because, while for both the earnings have gone up significantly, the income on the small farms has gone up even more. So the disparity between the haves, even those with a small plot of land, and the have-nots who only provide manual labour, has indeed increased.

There are some rather important implications of this. Wherever there are large farms, the need for labour during

certain seasons is, in fact, so great that mechanisation is taking place extensively, as in Punjab and other places. This is regarded as, and indeed in many cases docs, run counter to the interests of the farm labourers. Mechanisation is still not very widespread, but this is one of the things which is likely to take place and is going to create its own problems.

The increase in real wages has been at least five per cent per year during the last five years in these areas. This is a very significant aspect of the Green Revolution. But since 80 per cent of the farms are not irrigated, one of the first impacts has been increased disparity in the standard of living and culture between the minority in fortunate areas which have irrigation and the large majority of others without irrigation. If, as economists have classically done, we ask the question: Where would fresh investment give us the best incremental return, we nearly always come up with the answer which identifies farmers and com unities in the irrigated areas. Investment of Governmental funds on this basis would create tremendous imbalances and political instability in the country, as it has already tended to do,through creating some regions far more prosperous than others. To avoid it, one has consciously to adopt a policy of not looking merely for investments which produce the most short term return, but consider package investments in new areas, which would then bo able to catch up and emerge from their underprivileged position.

A rather interesting study was made recently, by a group of scholars from the Indian Institute of Management at Ahmedabad on the resistance to change, which is feared might impede agricultural progress. They compared, in a largo area in the Western Gangetie Plain the time at which new fertilizers were adopted and the time when new seeds were adopted. They discovered through

this study that, while this gap used to be as much as four years before 1965-66, today the gap between adoption of the two different inputs, both of which are necessary for optimum results, is no more than a year. From this they conclude that, at least today, the Indian farmer has no resistance to adopting new agricultural technology, that the return to investment ratio of these innovations is so great all over the country that it has carried its own message with it. There is a fantastic demand for water, for energy to pump water, for fertilizers, and for the new seeds. A most interesting report in the last two months is that in several areas traditional varieties of seeds wore sold to gullible farmers as being of the new hybrid variety and the fraud is only discovered some time after sowing is completed. The problem of selling genuine new varieties of seeds, which are moreover not infected, is a formidable one. Special measures have been implemented to ensure this.

Dr.Swaminathan, Director of the Indian Agricultural Research Institute, has written quite a bit on the synergistic package which is required before change can be produced in the countryside. In analysing the implications of the Green Revolution, the noted economist Dr. Raj wrote as follows: "New varieties yielded more, only with substantial complementary inputs of chemical fertilizers and other plant nutrients; and they, in turn, required assured supplies of water at specific intervals. Without such supplies, there was danger, not only of the complementary inputs becoming infructuous, but in some cases of the yield being lower than from the use of the older varieties without applying these inputs".

One of the important lessons, which has been learnt in the implementation of the measures which have contributed to the Green Revolution, is the recognition of the totality of the package which is required. It doesn't require much imagination to see that if all these inputs are to be brought simultaneously to a particular area, it requires rather new forms of central and local governmental organizations and administrative practices. This is at least as difficult as the task of creating the physical inputs which are required. In the Indian Atomic Energy Commission, we are studying intensively the need for water in large areas where surface irrigation is not possible or is already fully utilised. Fortunately for us, the Gangetic Plain is literally sitting on a lake of water. If one can pump this water out, with deep tube wells or shallow wells, one immediately produces a transformation in the agricultural scene.

It so happens that, in India, fuel resources are concentrated in particular areas of the country; they are by no means evenly spread about. There is at least a third of the country where, even today, atomic energy is less expensive than electric power produced from fossil fuels. Hydro-electricity is, of course, restricted to a few specific locations. Under these conditions, the Atomic Energy Commission has made a study of the typo of project which could be implemented if, in an area where there is subsoil water, we could provide extremely low-cost energy. We have completed a study of an Agro-Industrial Complex in Western Uttar Pradesh. The outlines of this are as follows. It covers an area inhabited by 24 million people. It is proposed to put up two nuclear power stations of 600 megawatts each and to

energize 25,000 tube wells. The power requirements of tube wells arc peaked at different times of the day and at different seasons, and it is proposed to provide a base load for the station, and also to use the surplus capacity of the station, by producing the other inputs required for agriculture: firstly, phosphatic fertilizers, by using the electrothermic process for elemental phosphorus. At the present time, India doesn't have important deposits of sulphur so that for producing phosphatic fertilizers using sulphuric acid, all the sulphur has to be imported. Low-cost electrical energy provides a different way of producing elemental phosphorus and this is, itself, not only a better process under the circumstances which we have stated, but is also economical for transportation. Of course, if we have very low-cost energy, then producing nitrogenous fertilizers from electrolytic dissociation of water is an alternative to *the* use of naphtha or fuel oil, which India has again to import as of now. There is still the problem of making electrolytic cells economical compared to some of the naphtha based plants. But the growth of technology of high capacity electrolytic cells has been promising. In consequence, the electrolytic propose is likely to at least break even and save foreign exchange. The return on investment in this complex will be 54 per cent on the incremental investment of about 1.5 billion dollars, but 50 per cent of this large investment is on the infrastructures of roads, railways and provision of credit. The complex will generate fresh employment for 1,4 million persons all year round. *It* will produce 9.4 million tons of food grain, 1,8 million tons of potatoes, 11.2 million tons of sugar cane. It will increase the GNP by 1.2 billion dollars annually. This is the type of complex, in which we have a totality of inputs, being planned to produce the type of change that we desire.

I would like, in this connection, to give an analysis of the formidable social problems that are involved in implementing a project of this type. Such a complex requires effort at a notional level, since the setting up of atomic power stations is the responsibility of the Central Government, Moreover, a large station of thousand megawatts capacity for generating electricity would have to be part of a super-grid connecting the important generating points feeding several States. Each State would have to have its own electricity plan, to receive and distribute power to the points at which tube wells would need to be constructed and energised. There would need to be local organisations for digging the tube wells on a cooperative basis and for maintaining them in good working condition. There would be need for hardware, the cables, the distribution towers, switch gear, pumping sets, piping for the tube wells. Unless everything is included in this total framework - from the mining of uranium to the production of nuclear fuel elements, the fabrication of power plants, erection and commissioning of the fertilizer plants, and the whole irrigation system - one cannot hope to achieve the results that the total system is capable of providing. It involves not only the diverse ministries at the centre, but diverse departments of State Governments, local governments, industries and cooperatives, not to speak of the effort that would bo required from countless private individuals.

we started with the Green Revolution; we are ending up with a social revolution of the first magnitude. In a country like India, provided political power is sensitive to the needs of

the underprivileged, provided it takes specific measures to see that the benefits of change do not go into the hands of the few, advanced technology in agriculture, as in power generation, is indeed going to generate a social revolution in our own time.

Remarks by Dr.Vikram Sarabhai, Chairman, Atomic Energy Commission, and Advisory Committee of the Nuclear Research Laboratory, at the inauguration of the Laboratory on 29th November, 1971.

Madam Prime Minister, Shri Fakhruddin Ali Ahmed, Dr.Eklund, Dr.Swaminathan and Friends:

Exactly five years ago to the day, I called on Shri C.Subramaniam, who was then Union Minister for Agriculture to discuss the organisational set up for the project which is being inaugurated today. To my delight, the Minister enthusiastically backed up the rather unconventional approach which I suggested. I followed up our meeting with a letter summarising this approach and I quote from it:

> "I feel that in whatever we do we should strive to intensify the research activities of the IARI as carried out in its various divisions with reference to the applications of radiation and radioisotopes in agriculture and provide a bridge between the activities of the biology groups of AEET and IARI. Accordingly a nuclear centre for agriculture will be established at Delhi and be under the administrative control of the Indian Agricultural Research Institute. It will be controlled in respect of policy and strategic decisions by a board (of six?) consisting of an equal number of representatives of the IARI, ICAR and of the AEET. This would ensure a true sharing of responsibility to make the new centre operate with the fullest backing of IARI/ICAR and AEET.
>
> 2. The new centre would receive the benefit of the facilities of both organisations as well as personnel, who may be seconded from the parent

organisations. It would be the objective of the control board to make the maximum use of facilities existing in the two organisations which could be supportive to the centre's programme. At the same time, the centre will create fresh facilities which will supplement the expertise and facilities at the parent organisations.

I believe that the effectiveness of Indian organisations to provide meaningful service for solving national problems would be greatly enhanced if opportunities are created through formal organisational links which provide partnership and collaboration on terms of equality between scientists at various levels drawn from collaborating organisations. It is indeed the only way in my opinion by which one can tackle the large number of real problems which are interdisciplinary in character. I was delighted at our meeting that you not only fully supported this view but advocated that similar experiments should be tried out in two or three other areas of national activities. I will report to you separately a project which we have already started as a joint venture of IARI, AIR and ESCES (Experimental Satellite Communication Earth Station) of the Department of Atomic Energy. This will attempt in the next few months to evaluate the effectiveness of television as an instrument for mass communication to implement measures for increasing food production.

I am aware that many problems of a day-to-day nature will arise in the setting up of the nuclear centre. I have no doubt, however, that it is only by working through these problems we would achieve the very important social change in the present system which is crucial for implementing many measures which we know would be useful. With this background, I am now passing over to

Dr.Swaminathan and Dr. Gopal-Ayengar to work out details of the scheme which can be sent to the international agencies for support."

By all accounts, the suceess story that we have here today is an impressive demonstration of what is possible if we are prepared to create organisations with operating cultures and traditions which are appropriate to specific tasks. Most meaningful tasks of national development rarely lie within the four corners of responsibilities of any one Ministry, as enshrined in the "Allocation of Business Rules." On the contrary, the overlap occurs not only amongst the Ministries and organisations at the Centre, but also these at the State and local levels. An organisation which has built into it the ideas of overlap, ambiguity and multiplicity of aspects which are not less orderly than a simplistic structure within a single national agency. They represent a thicker tougher, more subtle and more complex view of structure.

This is not the occasion to discuss organizational aspects in depth; but we should note that the moral of the story is reflected also in the international collaboration between the International Atomic Energy Agency and the Food and Agricultural Organisation of the United Nations, which are behind this project. The Atomic Energy Commission is itself concerned with four other projects of direct relevance to food and agriculture and to the development and welfare of our rural communities. There is the project for an Agro-industrial Complex in Western Uttar Pradesh

which will attempt through low-cost nuclear energy to provide lift irrigation and a number of other inputs such as fertilizers for producing an additional 5 to 8 million tonnes of cereals and an all-the-year round employment on farms for about 1.4 million people. There are projects for food preservation and sprout inhibition using radiation. There is the Satellite Instructional Television Experiment which would make available through a powerful audiovisual means new information inputs for increasing agricultural production to the isolated communities with a large population of illiterates. And finally, there is the programme of using space technology for hydrological studies and remote sensing of diseased and healthy crops as well as aforestation using infra-red techniques. In all these, we have a direct inter-face with the IARI, ICAR and the Ministry of Food and Agriculture.

I wish here to express to our sister organisations our pledge for continued partnership in the very worthwhile task of providing to the country the best that we can offer from the agricultural, nuclear and space sciences.

INAUGURAL ADDRESS BY DR.VIKRAM A.SARABHAI on the occassion of his inauguration of the seminar on "Current Developments in Underground Metal Mining Practices in India and Abroad" at Jaduguda on 28th October, 1971.

It is a particular pleasure for me to be with you this morning. I am very grateful for the invitation to inaugurate this seminar. No country can be self-reliant in nuclear matters unless it has its own resources of nuclear fuel. In Jaduguda, the venue of this seminar, we have the first and the most significant link of a chain of projects which are taking India to self-reliance in the applications of nuclear energy. This link depends on techniques of underground mining and extraction of uranium from ore of grade no richer than 6 parts in 10,000 which is only about a third of the average grade exploited in the world.

In natural uranium, the isotopo 235, which is the one responsible for fission, occurs only in a concentration of .7 per cent. 99.3 per cent of the uranium is not able to generate atomic energy by itself. Natural uranium at Jaduguda occurs only in concentrations of .06 to .07 per cent and you can therefore appreciate that what is useful for nuclear energy is a fraction - .7 per cent of .07 per cent of the ore that is lifted, which is just a few parts in a million. The economics of nuclear energy therefore is crucially related to the subject matter of today's seminar.

India's programme for nuclear power will have two stages. In the first, natural uranium would be burnt in Candu reactors to produce plutonium, which is a fissilt material like U235. Plutonium will be used in Breeder Reactors to generate more plutonium, while it produces energy. Thorium will be used with this additional fissile material to generate

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U233 in thorium breeders. We do not expect to reach commercial breeder reactors before 1980 or to use the thorium fuel cycle before 1985 and in this sequence of events, the mining and extraction of Uranium is the first step which we must undertake efficiently. The Profile of Atomic Energy Commission, approved by Government, calls for 2700 MWe of nuclear power by the end of seventees. With a doubling time of five years, compared to 7 years of the country as a whole for all energy resources, we need 44,000 MWe by the year 2000. Currently estimated uranium resources are adequate only for fuelling 10,000 MWe of the first generation reactors for 25 years of their life-time. This gap between what we need for our nuclear power programme gives urgency to the task of prospecting, mining and extraction of the natural uranium resources.

A mandate was given to Atomic Minerals Division of the Department of Atomic Energy about 1½ years ago to look not only for new prospects in established areas, but identify new locations through aerial survey and intensive ground prospecting. There is a national programme for this purpose involving all the various agencies. We are greatly interested and are actively participating in this. There is also the programme of deeper drilling to be undertaken in the existing projects. We have added 50 per cent to our estimated resources at Jaduguda by extending from 450 metres to 600 metres or more. We have ore of better grade lower down and this will off-set the higher cost of mining. We need a multi-agency approach for exploring our basic resources. One of the most unfortunate things is that so far we have not really come across any uranium ore which is comparable to the average in the world, which is .2 per cent. We have only .03 to .07 per cent. We have to use utmost ingenuity to improve this. It is here that we have a challenge to our engineers and scientists including biologists. It is necessary to go all-out and

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improve our efficiency in the mining and extraction techniques. Mechanisation of units underground is one of the best ways of bringing down cost of deep mining.

The technology of heap leaching is quite interesting to us and we are hoping that with experience, in a period of six months or so, we will establish a workable technology. Underground leaching has been suggested many. This may involve underground nuclear blasts. A large number of experiments have been conducted in the USA and the USSR using underground blasting for making large cavities and then pump an appropriate solution for extracting the particular material which is required. This saves a tremendous amount of labour. There are many hazards in the conduct of underground blasts. There is the danger of environmental pollution including water contamination through radio-activity. Before we can undertake practical demonstration of this technique, much study has to be completed.

The problem of by-products recovery is important to us. There are, in many cases, by-products such as Molybdenum, Nickel and Copper. We are very interested in these and are going to put up a By-Products Recovery Plant at Jaduguda. We can also use copper tailings for extracting uranium. In the new schemes that we undertake, we have to give greater attention than hitherto in order to make the whole process economical even though mineral may not be present in economical quantity by itself.

In the light of the 10 year profile of AEC, we are hoping to start the second stage of Jaduguda extending the working to *640* metres by 1976. The additional cost will probably be offset by the improved performance because of better ore. Narwapahar is to be opened up and developed into a fullfledged mine and mill with 1500 tons of ore per day. Work will start very soon.

The cooperation between different agencies in the whole task of identification and development of mineral resources has to be augmented even more. GSI bore-hole data has helped us in identifying the Turamdi Prospect which is most promising. Prospecting and surveying from air have to be undertaken involving other agencies and sharing of aircraft. The progress of the country in the future not only depends on the successful identification of resources, but also in the manner in which different organisations and a large number of public and private sector undertakings collaborate.

When we come to technological improvements, we have always been cautious. We need to acquire an innovative temperament and self-confidence, so that we shall not be afraid of making mistakes. Experience only will help us to correct these mistakes. People have to discuss the problems that they come across and I am sure that this seminar will help much in doing this. May I wish you a very successful seminar and I thank you again for inviting me to inaugurate it.

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SCIENCE POLICY IN INDIA

Background Paper Prepared for Talk

by

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Annual Meeting of Association of Asian Studies Boston, Massachusetts April 2, 1962

Reproduced for

Association of Asian Studies

by

COLUMBIA UNIVERSITY COUNCIL FOR ATOMIC AGE STUDIES 421 West 117th Street New York 27, New York

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GOVERNMENT OF INDIA

SCIENTIFIC POLICY RESOLUTION

New Delhi, 4th March 1958

The key to national prosperity, apart from the spirit of 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 in tense 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 com munity, 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 effect and re-sources 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 industrial isation. 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 manpower 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 industrial ising a country, a heavy price has to be paid in importing science and technology 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 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.

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

(i) to foster, promote and sustain, by 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 full 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 academic freedom, and

(vi) 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.

SCIENTIFIC RESEARCH

THIRD FIVE YEAR PLAN

Preamble

In the Second Five Year Plan, scientific research along with education, was dealt with under the general heading of 'Social Service.' But in reality scientific research requires separate treatment. The extent to which the sciences affect the life of all, even the humblest, in a modern industrial society is truly remarkable; they shape his Interests and aspirations, his work and achievements. Accordingly, in any plan for national development, scientific research must receive special consideration in Its own right.

2. The Second Plan dealt with medical research, agricultural research, forest research, research in the field of irrigation and power and In other fields separately and disjointedly. The fact that some of the scientific disciplines fall under different Minis tries of the Government should not stand in the way of a coordinated and integrated appraisal and formulation of a plan for future devel opment of science as a whole including all the basic and applied sciences, technology and engineering, in all their aspects, educa tion, research and application.

3. Secondly, scientific research cannot be isolated from the pattern and programme of education. The two go together. Our scientific output depends upon the quality and supply of scientists and technologists. The quality of our science and scientific educa tion cannot be divorced from the quality of our intellectual life generally, which in its turn depends on an effective national policy for education.

4. Thirdly, the Second Plan had not taken adequate notice of the close relationship of science and industry. This largely reflected the position obtaining in our country when the plan was under preparation. The technical devices which constitute the present economic and industrial strength of the advanced nations are the outcome of scientific effort; which, in turn, is strengthened and broadened by industrial growth. Hence, a plan of economic development which fails to take into account the mutually stimulating influence of science and industry on each other will be unrealistic. It is true that to some extent the growth and activities of national laboratories during the period of the Second Five Year Plan were reoriented with a bias towards industrial development and this has yielded some useful results. But to obtain the best results not only must this process be pursued further but industry and research laboratories should be so closely coupled as to energise each other. The roots of our Industry are embedded In the soil of science and technology of foreign lands; and if our industry is to thrive and grow it is essential that it should derive its sustenance from scientific efforts within the country.

5. It is being increasingly realised that industry and education should interest themselves in and contribute to the work of each other. One of the functions of educational institutions is to pro duce qualified and competent young men and women to fill scientific, technical and administrative positions in industry. Much of the technical and technological learning and all apprenticeship training is based on industry. The influence of industry and education on each other is bound to grow and this factor has to be taken into account in the formation of policies. It will help in healthier industrial growth; it will also lead to a sense of realism in the education pattern and curricula.

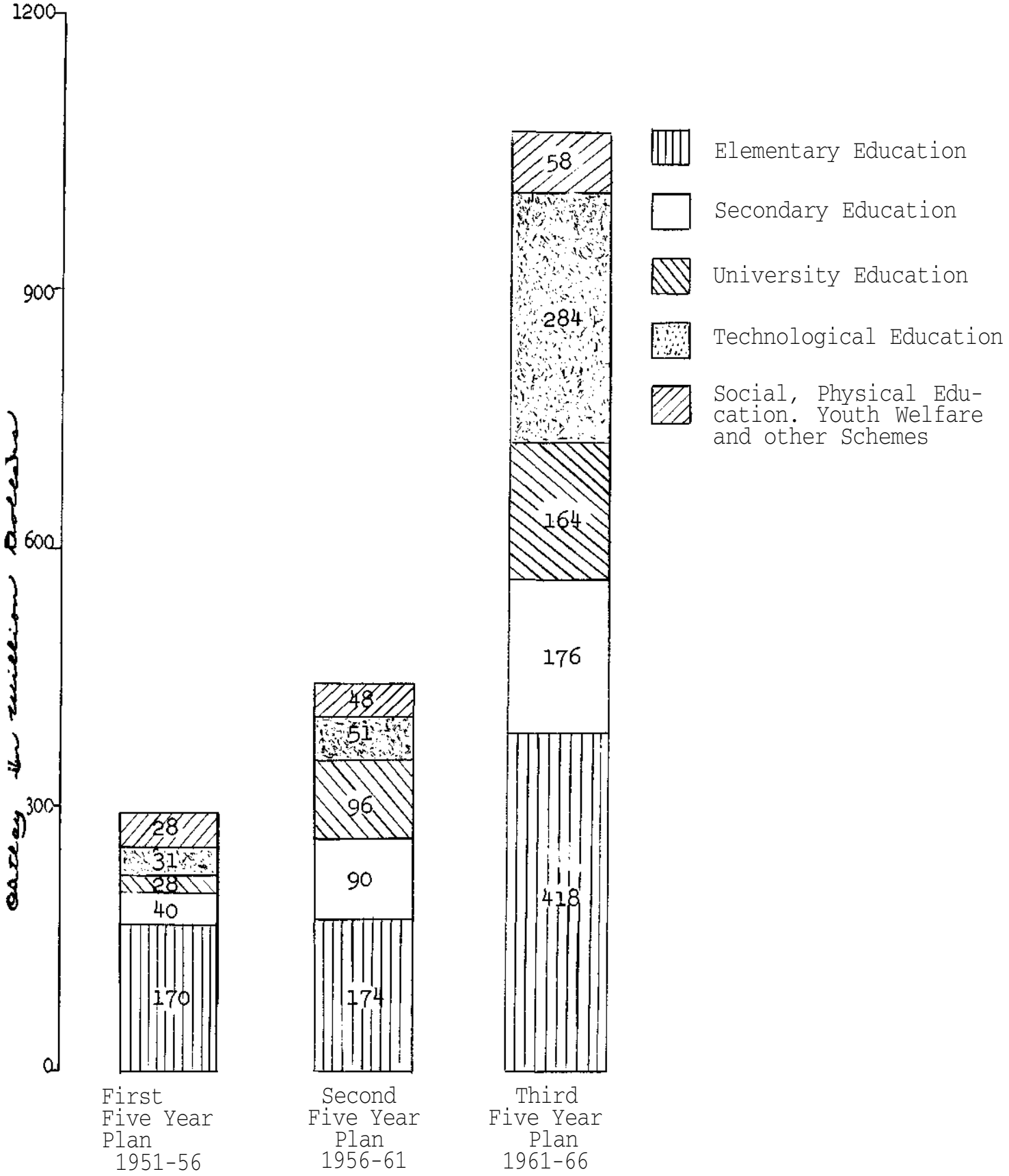
6. Education and training of scientists, technologists and engineers, advancement of basic and applied research on a large scale, and rapid and efficient utilisation of results arising out of such research for economic development and national welfare are but steps in the process of building up an industrial state. In the consideration of the developmental plans in the fields of education, scientific research, and industry, these basic concepts must not be lost sight of. Such an integrated approach will be a step forward in the mechanics of planning and an advance on the Second Five Year Plan.

EXPENDITURE BY STATE ON EDUCATION AND RESEARCH

3.a. Distribution of Outlay for Education in Five Year Plans,

	Amount in Million Dollars		
	First Five Year Plan	Second Five Year Plan	Third Five Year Plan
Elementary Education	170	174	418
Secondary Education	40	96	176
University Education	28	90	164
Technological Education	31	51	284
Social, Physical Education, Youth Welfare and other Schemes	28	48	58
Sub-total	297	459	1100
Cultural Programmes	-	8	20
Community Development and Welfare of Back-ward Classes	-	84	158
T O T A L	297	551	1278

DISTRIBUTION OP OUTLAY EDUCATION IN FIVE YEAR PLANS



3.b. Distribution of Recurring Expenditure on Education Incurred by State

	1956-57		1958-59	
	In million $	%	In million $	%
Universities	7.8	4.3	11.6	5.0
Arts & Science Colleges	9.1	5.0	18.4	8.0
Professional Colleges	10.4	5.8	14.1	6.2
Special Education Colleges	0.6	0.3	1.0	0.4
Middle & High Schools	57.7	31.9	73.7	32.0
Primary Schools	87.1	48.0	99.5	43.2
Vocational Schools	8.6	4.7	12.0	5.2
T O T A L	181.3	100.0	230.3	100.0

3.c. Resources for Scientific and Technological Research

	Amount in Million Dollars	
	Second Five Year Plan* 1956 - 61	Third Five Year Plan 1961 - 66
CSIR and Ministry of SR & CA	40	70
Department of Atomic Energy	54	70
Agricultural Research	28	53
Medical Research	4	7
Research under other Central Ministries	18	62
T O T A L	144	262

* Estimated Expenditure

NOTE: The Third Five Year Plan outlays are in addition to the expenditure amounting to $ 150 million during the Third Five Year Plan on the continuance of facilities established up to the end of the Second Plan.

4.

TRAINING

There are fifty Universities in India. The number of Universities according to category are indicated below:

Type of University	Number of Universities
Affiliating	1
Affiliating and Teaching	34
Teaching	15
T O T A L	50

The Staff-Student ratio was on the average 1:17 for the year 1960-61. The lowest ratio was 1:3 and the highest 1:24.

The enrollment in various faculties is shown in the following table:

Faculty	1956 - 57		1958 - 59		1960 - 61	
	Number	%	Number	%	Number	%
Arts	3,95,672	51.4	4,44,203	50.2	4,40,039	44.9
Science	2,10,039	27.3	2,38,292	26.9	2,94,898	30.1
Commerce	66,674	8.7	72,642	8.2	99,783	10.2
Education	13,000	1.7	13,630	1.5	14.534	1.5
Law	20,707	2.7	23,563	2.7	22,228	2.3
Engineering & Technology	21,237	2.8	27,523	3.1	35,052	3.6
Medicine	23,431	3.0	25,121	2.8	26,503	2.7
Agriculture	10,389	1.4	12,648	1.4	12,694	1.3
Veterinary Science	3,572	0.5	4,705	0.5	3,420	0.3
Others	4,747	0.5	22,229	2.5	30,378	3.1
T O T A L	7,69,468	100.0	8,84,556	99.8	9,79,529	1 .00.0

The annual output of Post Graduates in certain selected subjects is shown below:

Subject	1953	1955	1957	1959	1960
Physics	396	515	556	574	609
Chemistry	420	621	742	791	878
Mathematics	476	804	847	1,038	887
Statistics	68	78	174	170	186
Botany	214	243	265	371	372
Zoology	239	264	292	316	396
Geology	92	98	133	197	193
T O T A L	1,905	2,623	3,009	3,457	3,521

The output of Ph.D's and DSC's is shown below:

Year	Number of Doctorates
1951 - 52	190
1952 - 53	146
1953 - 54	250
1954 - 55	262
1955 - 56	285
1956 - 57	369

5.

SCIENTIFIC MANPOWER

There are 1,10,000 Scientists registered with the Council of Scientific and Industrial Research (CSIR). There are 6,090 Indian Scientists and Technologists abroad.

The Scientists in different disciplines as of January 1, 1962 is shown below:

Discipline	Number of Scientists
Physics	5,872
Mathematics and Statistics	5,170
Chemistry	7,754
Zoology	2,434
Forestry	616
Botany	2,303
Geo-Sciences	2,437
Agricultural Sciences	7,528
Others	652
Subtotal	34,766
Technology	6,519
Engineering	61,860
Medicine	7,829
T O T A L	76,208

6.

ACTIVITIES OF THE COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH (CSIR)

6.a. Expenditure of CSIR

The CSIR incurred a Development expenditure of $ 29 million during the Second Five Year Plan period (1956-61) and is committed to spend $ 106 million on Development during the Third Five Year Plan period (1961-66).

6.b. National Laboratories and Institutes Run by CSIR

The 30 National Laboratories and Institutes run by CSIR are:

(1) National Physical Laboratory, New Delhi

(2) National Chemical Laboratory, Poona

(3) National Metallurgical Laboratory, Jamshedpur

(4) Central Fuel Research Institute, Jealgora

(5) Indian Institute of Petroleum, Dehra Dun

(6) Central Glass and Ceramics Research Institute, Calcutta

(7) Central Food Technological Research Institute, Mysore

(8) Central Drug Research Institute, Lucknow

(9) Indian Institute for Biochemistry and Experimental Medicine, Calcutta

(10) Central Electrochemical Research Institute, Karaikudi

(11) Central Salt and Marine Chemicals Research Institute, Bhavnagar

(12) Central Leather Research Institute, Madras

(13) National Botanic Gardens, Lucknow

(14) Central Building Research Institute, Roorkee

(15) Central Road Research Institute, New Delhi

(16) Central Electronics Engineering Research Institute, Pilani

(17) Central Public Health Engineering Research Institute, Nagpur

(18) Central Mechanical Engineering Research Institute, Durgapur

(19) National Aeronautical Laboratory, Bangalore

(20) Central Mining Research Station, Dhanbad

(21) Regional Research Laboratory, Hyderabad

(22) Regional Research Laboratory, Jammu

(23) Regional Research Laboratory, Jorhat

(24) Central Indian Medicinal Plants Organisation, New Delhi

(25) Central Scientific Instruments Organisation, New Delhi

(26) Birla Industrial and Technological Museum, Calcutta

(27) Central Board of Geophysics, Calcutta

(28) Indian National Scientific Documentation Centre, New Delhi

(29) Rain and Cloud Physics Research Unit, New Delhi

(30) Genetics and Biometry Unit, Calcutta

6.c. Research Committees

The CSIR has set up Research Committees in each field for scrutinizing Research Schemes and sanctioning financial assistance. The Committees are:

(1) Aeronautical Research Committee

(2) Biological Research Committee

(3) Civil Engineering and Hydraulics Research Committee

(4) Chemical Research Committee

(5) Electrical and Mechanical Engineering Research Committee

(6) Geological and Mineralogical Research Committee

(7) Metals Research Committee

(8) Pharmaceutical and Drugs Research Committee

(9) Physical Research Committee

(10) Public Health Engineering Research Committee

(11) Radio Research Committee

(12) Joint Committee of the Indian Central Oilseeds Committee and CSIR on Vegetable Oils Research

(13) Advisory Committee of Rain and Cloud Physics Research Unit

(14) Wind Power Sub-Committee

(15) Coal Blending and Coking Research Sub-Committee

6.d. Sponsored Research

During the Second Five Year Plan the CSIR provided $ 37 million for sponsored research and $ 11 million for special research programmes.

The number of Research Schemes approved and expenditure incurred are given below for each year.

Year	Number of Research Schemes	Expenditure in million dollars
1957 - 58	304	9.4
1958 - 59	310	5.5
1959 - 60	390	6.2
1960 - 61	363	8.0
1961 - 62	486	10.6*

* Anticipated expenditure

The breakdown of Fellowships granted by CSIR is as follows

	Fellowships		
	Senior	Junior	Total
Research Schemes	67	214	281
Fellowships in Universities and other Institutes	95	366	461
National Laboratories and Institutes	30	138	168
T O T A L	192	718	910

In addition to the Fellowships indicated above, the CSIR is giving financial assistance to 30 Retired Scientists for pursuit of research.

7. THE ATOMIC ENERGY ESTABLISHMENT

The expenditures of the Atomic Energy Establishment during 1960-1961 were about $10 million. The activities are as follows:

(a) 1 MW swimming pool reactor

(b) 40 MW CIR natural uranium fuelled, heavy water moderated water cooled reactor. Production of radio-isotopes

(c) Zerlina. A Zero Energy reactor for lattice investiga tions and new assemblies. 100 watts.

(d) Uranium metal plant

(e) Fuel Element Fabrication Plant. Capacity 30-40 tons of Uranium fuel elements per annum. Supplied fuel elements to Zerlina and CIR.

(f) Heavy water reconcentration plant

(g) Nuclear Physics Division with 5.5 Mev. Van de Graff Accelerator.

(h) Electronics Division with reactor control, research and development, and production sections.

(i) Health Physics Division with a Radioactive Hazards Control Section, a Radiological Measurements Section and an Air Monitoring Section.

(j) Technical Physics Division with a Vacuum Technology Group and a Crystal Technology Group.

(k) Analytical Division

(1) Chemistry Division

(m) Isotope Division with a Labelled Compounds Section.

(n) Radiochemistry Division

(o) Chemical Engineering Division

(p) Metallurgy Division

(q) Engineering Services Division

(r) Reactor Engineering Division

(s) Biology Division

(t) Medical Division

(u) Training School

A 300,000 kw. Atomic Power Station is being set up 60 miles north of Bombay

INDIA AND THE BOMB

Dr. Vikram A. Sarabhai's Press Conference

Bombay, June 1, 1966

Obviously I have come with the expectation that this is going to be a very challenging job. It interests me very much because it provides an opportunity for carrying on the work which Dr. Bhabha started, and I think this is very crucial to the development of our country. I am also very interested in the total problem of science and society and the application of science to the various real problems of the nation. I think that this job provides me with this opportunity. And of course it is an inspiring thing to work for a person who, herself, is trying to lead India through one of the most difficult periods of its existence, and this calls for cooperation from everybody who can apply himself to this task. My own past relationship with the work of the Department has been mainly in the area of space research, and even though I did my Doctorate in an area of nuclear physics, in photo fission of uranium at Cambridge, my later professional interest as a scientist has been more in the field of solar activity and physics of the inter-planetary space. But there were two experiences in my life : one with the Ahmedabad Textile Industrial Research Association which involves applying science to industry, when I was its Director from its beginning; and the other as the Director of the Indian Institute of Management, with the problems of management. This has really given me a lot of interest in the field of management of research institutions, in the management of Governmental organizations which

deal with task-oriented responsibilities, and I am hoping that this position will provide an opportunity for the first time in trying to really apply these experiences in collaboration with the tremendous band of talented young people who are here, both scientists and administrators.

I have talked enough, you can now ask some questions.

Q. What about the atom bomb?

A. You must forgive me if I preface this answer with something which you think is not a direct answer. I would suggest that we should ask ourselves the question : Why do we want an atom bomb? It obviously is a means to an end, it is not an end in itself. Everybody was horrified at the tremendous damage that was done in Hiroshima and Nagasaki. I do not think there are too many people in this world who would view this as a satisfactory way to live with; but we are all interested in security and I think it is legitimate for nations as well as individuals to defend their security, to see that all nations and territories, their ways of life, their freedom, are not encroached upon. But here I would like to emphasise that security can be endangered not only from outside but also from within. If you do not maintain the rate of progress of the economic development of the nation, I would suggest that you would face a most serious crisis, something that might disintegrate India as we know it. I would like to suggest then that when we set ourselves the goal of looking after the security of the nation, we should think of both internal as well as external threat, and this immediately brings about a very special

nature of the problem about which you asked the question. How do you produce a balance of internal development as well as maintain an adequate state of preparedness to resist aggression from outside? Do you have to do this all by yourself? To what extent would you use assistance from outside, whether it is for national development or for defence? These are the million dollar questions before us. So the real problem in this whole question relates to the utilization of national resources for productive and social welfare against the burden of defence expenditure which a country can bear at any particular time. Now I think those who are studied military strategy would all agree that paper tigers do not provide security, that is you cannot bluff in regard to your military strength. If you want to rely on the atom bomb for safeguarding your security in a sense that say the USA or the USSR have got, a series of balanced deterrents; this is not achieved by exploding a bomb. It means a total defence system, a means of delivery in this case. You have to think in terms of long range missiles, it means radars, a high state of electronics, a high state of metallurgical and industrial base. How do you develop such a system? It is not only for the scientist to produce one prototype, and you then have a defence system. It requires a total commitment of national resources of a most stupendous magnitude, and so the cost of an atom bomb is really not very relevant to this issue of whether you go in for it or not. It is tied up with much wider issued, if I might suggest. You can ask me what is the price of two yards of cloth, but the two yards of cloth cannot be produced unless you have a loom or a mill or something else behind it. In the same way,

if you want to produce a defence system based on nuclear deterrents of the type that the USA or the USSR has, then you know what their budget is. They are not throwing money down the ocean. They are spending it on hard military decisions, and the budgets run into several tens of billions of dollars. I think India should view this whole question in relation to the sacrifices it is willing to make, viewing it in its totality, I fully agree with the Prime Minister in what has been reported in this morning's papers. It is perfectly correct when she says that atomic bomb explosion is not going to help our security. I fully share this feeling,

There is no straight answer to this question, because the thing is so complex.

Q. Assuming that the Government of India changes its mind, how long will take to make the bomb?

A. It depends on how much effort it is willing to put. If I ask you to build a house and if you put ten masons, you can build it in a certain time. If you put one mason, it will take a different time. The whole thing is related to total national resources, what you are willing to commit. To answer this is a different "ay, I have no doubt that Indian scientists and technicians are among the best in the world and, given the opportunity and the facility, they would certainly undertake any task of scientific and technological development which is called for. You have seen it before your eyes that given the type of conditions they require, not only the brick and mortar, but the social and cultural conditions, and I think Dr. Bhabha was most successful in providing within the Department a new culture in which these things

could happen, a self-reliance would be developed. So, given all these things, provided the nation is willing to put behind such measures adequately, you will get an answer which is appropriate to the effort you put in.

Q. ....

A. It is not for a scientist to make such decision. It requires a total commitment of the nation.

Q. How long will it take to develop a missile system and how much will it cost?

A. To undertake a missile system? Not under the present state. We do not have the industrial base today, you can see the Electronics Committee Report which has just come out

Please be very clear, I am not talking of a prototype. I am talking of a system such as the USA has got, just imagine what it means. It means an early warning system. It means a most sophisticated type of system. 11 this requires an industrial base of the most sophisticated type. I think we have to go step by step, We can only go step by step. It is not the question of having to or wanting to. In developing our grass roots economy, we have to first of all develop metallurgical base and an electronics base, and all this cannot be done without a good agricultural base. I do not see how you can be for all these things unless the country makes more gross national product.

Q. What is our capability for a prototype?

A. Prototype, of course, we can make, but then I would suggest it is a paper tiger.

Q. Prototype is a paper tiger?

A. Yes, what else is it?

Q. What is your opinion about the Chinese atom bomb?

A. The Chinese are developing a system today. Well it is very well known that Chinese social and economic system is totally different from ours.

Q. Was the Chinese bomb a hydrogen bomb?

A. From the reports we learn that it was not a thermo-nuclear bomb. This is the general outside opinion.

Q. Did we get any samples of fallout in our country?

A. Mr Sethna : We have picked up the samples. They indicate that they have used U-235 as they did in the previous bombs. This time they tamped the bomb with U-238 or put a casing of U-238. In the previous two tests also they have used U-235 but this one is a much bigger explosion, in the neighbourhood of about 200 kilotons, and the first two were in the neighbourhood of SO or 40 kilotons roughly. This would indicate an attempt on their part to go in for what you might call a hydrogen bomb or a fusion device, but it does not seem to have come off successfully.

Dr Sarabhai : I would suggest that this is the technical aspect, and if you like, you can request Mr Sethna later; otherwise it is likely to confuse you. I feel that the press has a tremendous importance provided that what they report is authentic; otherwise it can create misunderstanding. So if you are interested in anything, and if you are going to quote it, I think it is better that we give a little time to it.

I want to come back to the previous question; I want to emphasise one thing. I started with the hypothesis that your question was related to ensuring India's security. To these who advocate it, I want to say that India's security is both internal and external and you have to consider both these factors. To ensure the security requires a balance between economic growth and military preparedness. Our problem today is to try to find the right balance. One atom bomb explosion does not constitute increased security. If you want security on the basis of what the Americans and Russians have, then the meaning of this is quite different and the cost of this is known to you, and this is what I was trying to say.

Q. ....

A. Did you know the cost of Americal military budget for security? If you are thinking in terms of China, or any of the big powers, then you have to have something comparable to it. You have to have hardened missile bases and all the rest of it.

Q. Dr. Bhabha had said that the cost of an atom bomb would be Rs 18 lakhs?

A. He said what he meant. It was his estimate that this was the cost of putting together a prototype.

Q. You are not for a prototype?

A. I am not for a prototype? I did not say that. I do not think these are scientific decisions you are asking now. I think these are political decisions to be made because they are tied up with, as I said, the total problem of what is the type of commitment and sacrifice India is prepared to make. It is not surely valid.

Q. Are you prepared to catch up with China?

A. Well China, I am told, has the most important electronics industry. Electronics are the hardware of all modern technology and science. They go into computers, they go into control systems, guidance and all that. You will see our report, and it shows that we are in the most elementary stage. But I am not saying, therefore, that we cannot do it. My own feeling is that the country requires to develop its grass roots technology side by side with its advanced scientific development, and that this technology will feed back into the economy and produce tangible results. If you have a good electronics industry, it will give you much better returns. It might give you the media, the means for mass production which you can use for implementing your policy for increased food production, animal husbandary, and population control. These are all the things which will be the immediate gains. These are all the things which will help your total defence and security questions. Whether you want to go at one stage for one thing or the other that is a matter of detail. If you are wise, you will select the means which will give you the most effective retaliation.

Q. What are the prospects of linking a full-fledged nuclear programme to peaceful uses?

A. Defence system with peaceful uses? What do you mean by this?

Q. Are we going in for a nuclear bomb or not? Are we capable of producing one or not?

A. I think I answered this. I said that capacity depends on

comaitment. It depends on political decisions made. It is political decision and it is a social decision too. If you are really thinking of nuclear defence system, I would be very clear in saying that it will do you more harm than good. If you ever think of it, think of spending 40 or 50 billion dollars a year. That is a different matter.

Q. What about Pugwash Movement?

A. I am all for collective security, for developing every possible way of working through peace. If I feel that the greater good of the world as a whole, will be served by a particular course of action, I would support it. Q. ...•

A. I do not see things in the white and black sense. I think in terms of weighing up the pros and cons. My feeling is, and I think this is shared by most people, that atomic warfare is one of the biggest threats to the survical of human beings. If atomic warfare were to break out on a global scale, this would be a terrible catastrophe for the world. I have no hesitation in saying this and this is not a very original statement. It has been repeated by many people. I, therefore, say that everybody has a responsibility to see that the world does not go towards the path of endangering our survival. It is as simple as that, Q. ....

A. It is premature for you to ask me this. I think a very good foundation has been laid down. So many things are going on : there is a Tarapur, there is the Rajasthan, there is the Madras Atomic Power Project. These are all ambitious projects, plus all that atomic

energy is doing and planning to do in relation to the development of basic materials, fuel and other things. I think we are in a very good state.

Q. The Plutonium Plant at Trombay has been operating since two years now The plutonium produced in this plant will be used in the second generation of power reactors. Could you please tell us when India intends to export plutonium?

A. May I say now that you are going into areas which are quite detailed, which you cannot expect a man to be able to answer off hand* I think you would appreciate it is no use answering unless one has studied this issue in detail.

Q. Uranium Purity?

A. If you put uranium in a reactor, you have to have it of a certain purity. No, we have no diffusion plant for concentrating uranium,

Q. If India decides to go in for the bomb, it cannot develop the industrial potential overnight?

A. It depends on how keenly you want it. If you were to take a decision that you want to take away every scientist from all the universities and everywhere and put them in a group to develop the electronics industry for this or that, that is wonderful type of commitment. I agree that there is an intrinsic time to develop a project; I am not denying that. But I feel that these things have to be developed for their own economic reasons, and not because we want to build a bomb. I think it will help our defence potential, and make possible many improvements in our total domestic scene, if we were to up some of these key elements, strategic elements, alloys, steels,

electronics, special grade materials, these things which are absolutely essential plus, of course, things like fertilizers.

Q. Nuclear Umbrella?

A. If you are going out in rainfall and were carrying your umbrella, you might have some confidence in you. If, perhaps your son was carrying an umbrella and holding it over your head, you might have a different degree of confidence. Some son might run away if there was a game. If you had a complete mercenary carrying an umbrella and there is a typhoon, he might be holding it on his head rather than on your's, so that the whole aspect of an umbrella is not a simple question. It means a question of confidence, of faith, of how credible a guarantee can be, and this is linked up not so much with paper agreements as I see, but what are the national interests of the nations who are providing this. I am not against umbrella, all I am saying is that if you are looking for security, you must look for security which will provide security. If you can sleep well at night, this is fine.

As I have said, presumably those who advocate an atom bomb are saying so because they feel insecure. If you can create conditions for them through any circumstances, understanding with other nations like the US which can substitute the security which they hope to get from the atom bomb, then I think it is a very useful thing. Then it is a substitute, isn't it. But it is dependent on what exactly it is, who is giving it, how is it given.

Q. ....

A. I am not for paper tiger? They are dangerous. This is a very

delicate subject. If you wish, I am ready to dictate my thinking on this matter. It will be authentic. You will appreciate that one does not want to create a misunderstanding. That is why I will give you a written statement. (See Appendix I)

Q. Could you tell us, as the new Chairman of the A.E.C., do you have any new ideas or new proposals you want to carry out, or give this programme a new sense of direction?

A. It would be very foolish to speak about this new sense of direction. I think my main task now is to carry out Dr. Bhabha's programmes forward. When Dr. Bhabha died, there were a number of projects with A.E.C. I think these have to be carried forward with great energy and dynamism, and this organization has shown that it can do it. I do not think that the Chairman does this. I think that the Chairman can only produce some of the things that will help others to do it. If I can succeed in producing the ecology in which the people who have the ability will offer their best, I think I would have done my Job.

Q. What about our morale?

A. The question of morale is a good one. I think it is necessary for every nation to have self-respect, and be able to hold his head high. I think this is necessary; I am not denying it. I am also fully conscious that there is a widespread feeling of consternation that we are being outstripped by our neighbours. I think that we have to bring out our progress in real terms, meaningful to the nation and the vast number of people, not in terms of gimmicks. This is what I mean, and I think we should keep up our emphasis on realities and not on show.

You do not want window-dressing, if you want to keep up your morale for long. My feeling is that science and technology have a tremendous lot to offer today for the development of a nation in every field, not only in atomic field but in many others.

It should be out task, whether we are atomic physicists or not, to really apply ourselves to these problems. If we can do this, **we** would have enhanced our security both internal and external. This is the moral of the story.

In reply to another question Dr. Sarabhai said that it should be our task as scientists to bring before the nation, and the people who make the decisions in regard to commitments, the type of alternatives they have in terms of promoting schemes of application of science and to create an environment in which this application can take place. This is where we have a tremendous lot to do, and which interests me very much. I thick this is what to me means planning.

Q. Do we have any programme of plasma research in the country?

A There are some people interested in this thing. For instance my research in relation to interplanetary magnetic field is related to solar plasma wind. It is not the same thing as hydrogen bomb plasma. But what I am trying to say is that as of today I am right in saying that we have some theoretical people who are interested in the problems of plasma physics in the country. We have some people just as I who are studying problems related to plasma in the interplanetary space, but I do not think that we have today, unless I am mistaken or I do not know, what I would call a very active experiments school of plasma research. This is a very fascinating field because

obviously in the long range controlled fusion as an energy source is going to be very interesting.

Q. Will you throw some light on our space programme?

A. I will be very happy to explain to you the objectives of our space programme, but we have already spent 45 minutes. I am not trying trying to hedge you. I think it is a very fascinating application of the peaceful uses of outer space into meteorology and aeronomy. Let us discuss this subject some other time.

Q. What about desalination research?

4. I was in England only about 10 days ago and the British have published a lot of literature on the subject. Sir John Cockcroft has just published a paper on it. There is a tremendous interest today in the problem of linking desalination with the generation of electricity. And this is probably of no such great immediate importance in England as it might be in some special areas, but the British are doing a great deal of work in this field, and other countries too. It seems to me that in India we would do well to look at this problem quite seriously. I do not know at this moment what degree of effort we could or should put in, both in research and development, but I am sure that something has been done.

Mr H.N. Sethna : We have worked out the economics for Madras, whether we should go in for a desalination plant, but they are so short of power in that region that it would not be worthwhile at this stage. Desalination means that you would have to go in for a big chunk of power, say about 1,500 to 2,000 Mile. This would mean putting up the entire present electric system in Madras at one power

station, which at the moment is quite a difficult task. We need to have a reactor 1,000 to 1,500 MWe for this purpose. Suppose this station falls out, there would be a complete blackout all along the line. You have to go slowly. For desalination through nuclear power, you take sea water and pass it through a system of a flash evaporator using surplus steam from the reactor. Mr. Meckoni has done some work on the economic aspects of this problem.

Dr. Sarabhai : In England they have worked out the cost. It would be about 4 sh. per 1,000 gallons since they are planning big reactors. This is obviously too expensive for agricultural purposes. If it comes down to something like 2 sh. per 1,000 gallons, then it would compete with the water you have for industrial purposes. I think Bombay supplies water to industry at Rs 1.50 per 1,000 gallons, or 2 sh. per 1,000 gallons. With the state of art improving, it seems reasonable to expect a desalination plant to supply water at about 2 sh. per 1,000 gallons, comparable to the water used for industrial purposes.

Q. 4 sh. might be high for industry, but in certain areas of India where people have no drinking water, it may be economic?

A. Then that is a question of balancing industrial power with domestic water supply. You generate power and you take out some heat energy and use it for distillation. It is very important for us to continue to study this problem in India. In fact this should be one of our major problems.

Mr. Sethna : There is ft whole Group working on this problem at Trombay. It is doing feasibility study to see what are the broad

economics, the technical economics, of this problem.

Dr. Sarabhai : Although I know how important the press is, I will appreciate if you give us a chance to do some work first and achieve something before giving it wide publicity.

Thank you very much.

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APPENDIX I

I expect that those who advocate that India should explode an 'atom bomb' must do so because of the wish to ensure the security of the Nation. In this connection one has to realise that the threat to our security arises from external as well as internal causes. If, for example, we are not able to maintain a steady rate of economic develop ment and provide social services we might have a most serious crisis in the country and a very great threat to our internal stability. The difficult thing is to establish a balance between investment for economic growth and development, and expenditure for military preparedness.

2. You asked the question about the cost of an atom bomb. I would like to suggest that if it is security we are after, and we choose to adopt arms control through nuclear deterrents, we need not just one atom bomb, but a total defence system. This involves atomic warheads, long range missiles for delivery and radar early warning systems. If one is thinking of atomic defence against one of the major powers, it is well known, from the experience of a country such as the United States, that the cost of this runs into many tens of billions of dollars per year. Unless one establishes a defence system, one is only creating a paper tiger. I think most people will agree that this is dangerous and cannot ensure real security. I, therefore, fully share the opinion expressed by the Prime Minister, as is reported in the papers this morning, that an atomic explosion would not increase our security.

Questions have been put here regarding the time it would take to establish a military system based on atomic warheads. In the

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first place this must depend on the amount of commitment of resources which one is willing to make and the sacrifices that this would entail in social and economic terms. But even if a country were willing to make economic sacrifices, it is absolutely essential to develop a basic industry in areas such as electronics and metallurgy, in addition to many other advanced technologies before a Nation can hope to deploy such a system. The necessary industrial base does not exist in these areas at the present time in India as has been well brought out in the Report of the Electronics Committee, which has just recently become available to the public. These technologies are essential for economic development as well as for defence using conventional armaments, and it would seem to me that we should give some priority to press ahead with projects which would achieve this dual objective.

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ORGANIZATION FOR DEVELOPMENTAL TASKS: ATOMIC ENERGY COMMISSION OF INDIA

Kamla Chowdhry and Vikram Sarabhai

IT is a common observation that understanding of the human factors of growth of institutions has lagged far behind advances in science and technology. Certainly some of the most perplexing and urgent problems of our time are not technological but human, organizational, social and political. One way to advance our understanding of the growth of institutions is through a wider sharing of knowledge gained from meaningful experience.

This article is presented in this spirit of sharing the meaning of a comprehensive experience. At one level it is the story of atomic energy in India, at another level the story of Bhabha, the great innovator and organizer, and yet at another level, of the growth of institutions and the introduction of change based on advanced technologies.

One often talks of the imprint of the personality of a man on the organization he has created. Surely, what is referred to is the manner in which his assumptions concerning the task and the motivations of people are translated into a management system. Decentralization, delegation, reporting and control, evaluation and motivation are aspects of the management system closely related to the objective of an organization. They also bear the imprint of assumptions which arc made concerning the task. At one end of the spectrum are certain administrative services, acting on past precedents and traditions providing security and continuity, impersonalized 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 organizations based on research and development, involving individuals who act on insights and hunches,

non-conformists questioning assumptions, innovating and learning. The two extremes require organizations and working cultures which are rather different. Yet many tasks encountered in the contemporary world call for organizations 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 also 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.

This article examines the assumptions which influenced Bhabha's strategy when he created the Atomic Energy Commission, the Department of Atomic Energy and the Atomic Energy Establishment at Trombay. It follows how strategy was translated into organizational structures and administrative practices. Moreover, it discusses the implications of his assumptions and strategy indicating their relevance .0 other organizations and tasks.

APPROACH TO DEVELOPMENT OF SCIENCE[1]

The initial conditions for developing institutions based on modern science and technology are somewhat different in India (and many other developing countries) as compared to the more developed countries. Even though there is a substantial base of those who have a University degree, there is a shortage of competent scientists, technologists, and administrators. Bhabha emphasized that in India, the first step in building institutions was the training and development of people. In the Tata Institute of Fundamental Research, the first Institute Bhabha started in 1944, he brought together a group of young scientists who were given all the facilities and freedom to develop research and to develop "second generation" scientists. From the beginning he was careful not to take scientists away from universities, for he believed this would weaken the universities and consequently any programme of development of scientists in India. He worked towards strengthening the relationship between the Tata Institute of Fundamental Research and universities.

On the other hand, many national laboratories were at that time filling their senior posts with mature scientists from universities.

[1] This section is largely based on Bhabha's paper "Science and the Problems of Development", Bombay, Hind Kilab Press, 1966.

Bhabha said, "the attempt to fill senior posts by mature scientists from outside must inevitably lead to their being taken away from the only institutions which have scientists in some measure, however inadequate in an underdeveloped country, namely, the universities". Headded that this step by the national laboratories had resulted in a weakening of universities by taking away their (universities) most valuable asset.

In starting a new institution Bhabha considered it important to build the organization around people rather than draw an organization chart first and then fill in the vacancies. In discussing the Tata Institute of Fundamental Research he said, "No organizational chart of the future development of the Institute was submitted either when it was founded or later, and the philosophy has always been to support ability whenever it is found in the fields of work covered by the Institute. Indeed, the philosophy underlying the founding of the Institute was the same as that underlying the Max Planck Institutes in Germany, namely, "The Kaiser Wilhelm Society shall not first build an institute for research and then seek out the suitable man but shall first pick up an outstanding man, and then build in institute for him'."

Two examples are given of building projects and development around people. To quote Bhabha:

(1) "As earlyas June 1944, Sir A. V. Hill had written to me sug gesting that biophysics was a neglected subject in India and that it should be taken under the wing of the Institute. While I agreed with his suggestion, I did not think that it would be wise to embark on this line till someone was found, mature enough to be able to work on his own and build up a group. When, however, in 1962 my attention was drawn by the late Dr. Leo Szilard to a very promising Indian mole cular biologist, it was decided to start work in microbiology, which has since then been growing very satisfactory.

(2) "Four Indian radioastronomers had jointly written identical letters to the Chairman of the University Grants Commis sion, the Director General of the Council of Scientific and Industrial Research, and to me as the Chairman of the Atomic Energy Commission offering to return to India as a group and establish radioastronomy here, if facilities and support could be given to them. Having ascertained that the members of the group had considerable original work to their credit and were of sufficient maturity to be able to work on their own in India, it was decided to take up radio-astronomy at the Institute."

With such an approach only the broad lines of work were laid down and the greatest possible freedom was given to the staff to develop new ideas and fruitful lines of work. Institutions grew on the ability of various groups to expand fruitfully.

Equally important was Bhabha's approach to administration of scientific research and development. He said that it is a fallacy to believe that "we are reasonably advanced in administration but backward in science and technology". He was aware that different tasks and institutions required different types of administrative practices, and that the transfer of government administrative practices, either to industrial enterprises or research and development produced inefficiencies and lack of morale.

Thus he said, "The type of administration required for the growth of science and technology is quite different from the type of administration required for the operation of industrial enterprises, and both of these are again quite different from the type of administration required for such matters as the preservation of law and order, administration of justice, finance, and so on. It is my personal view, which is shared by many eminent foreign scientists, that the general absence of the proper administrative set-up for science is a bigger obstacle to the rapid growth of science and technology than the paucity of scientists and technologists, because a majority of the scientists and technologists we have are made less effective through the lack of the right type of administrative support. The administration of scientific research and development is an even more subtle matter than the administration of industrial enterprises, and I am convinced that it cannot be done on the basis of borrowed knowledge."

Bhabha introduced administrative practices in the Tata Institute of Fundamental Research and later in the Department of Atomic Energy, which were alien to established university and government procedures. Scientists and engineers were paid according to their merit and maturity, rather than in terms of organizational position and status. Promotion did not imply handing over charge of one task and going over to another. Positions were created whenever competent people were available for identified tasks. As with personnel functions, Bhabha established for procurement as well as for civil construction procedures in which major decisions were taken by the scientists concerned.

Another factor that was important in Bhabha's approach was to provide to scientists and technologists opportunities of building their own know-how, of minimizing dependence on foreign know-how,

and of gaining experience even at the risk of failures. Thus, he said, "the emphasis has been throughout on developing know-how indigenously and on growing people able to tackle the tasks which lie ahead. The generation of self-confidence and the ability to engineer and execute industrial projects without foreign technical assistance have been major objectives." The Apsara reactor with its control system, which was decided to be built in 1955 "was entirely designed and built by our own scientists and engineers in just over a year". Regarding the control system for the reactor he said, "the important fact remains that the original control system even if more cumbersome and less elegant gave trouble free service for four years, and the confidence gained in doing it oneself fully justified the course that had been followed". Similarly in discussing the fuel fabrication plant built by the scientists and engineers at Trombay, he said, "producing fuel elements (from nuclear grade uranium metal) at a time when there were only about half a dozen countries in the world producing their own fuel elements added further to the self-confidence of our staff to undertake difficult tasks". To quote further his approach on foreign assistance:

> "The recent stoppage of foreign aid has shown our tremendous foreign dependence on a vast variety of materials and equipment, many of which could and should have been produced in the country long before this. We have found that a very large number of them can be produced as a result of the know-how which already exists in scientific organizations here, and steps are being taken to produce these in the country without foreign assistance. The results will show themselves within the next few years, and I have no doubt that the confidence which Indian technologists will gain thereby will spread to Indian industrialists and administrators, many of whom not having any basis of technical judgments of their own, are inclined to play safe by relying on foreign consultancy. Many examples can be given of foreign collaboration resulting in badly engineered plants or technical mistakes, and when such technical mistakes are corrected the foreign consultant benefits from the experience. Whereas, if an Indian scientific or engineering organization had been employed, the experience gained even from initial failures would have been a gain to the country. The Soviet Union did not hesitate to follow this path. One should also remember that in buying foreign know-how one is paying for an element which covers the cost of research and development done by the foreign consultant, and it is clear that a more permanent benefit would result to the country if this money were made available for supporting research and development in India."

The importance of Bhabha's approach as applied to industrial development is even more significant.

> "The steel industry has existed in India since the First World War, and one of the two steel plants was among the largest in the British Commonwealth in the early twenties. Yet, when these steel plants had to be expanded, it was necessary to draw upon foreign consultants and engineering firms to plan and carry out the expansion. When the Government decided to establish a steel plant in the public sector at Rourkela, a German consortium had to be asked to undertake the job. For the next steel plant with Russian technical collaboration. The third public sector steel plant at Durgapur had similarly to be set up with the help of a British consortium, and essentially the same method is being followed with regard to the fourth public sector steel plant at Bokaro. Thus, the construction and operation of a number of steel plants has not automatically generated the ability to design and build new steel plants. Unless powerful scientific and engineering groups are established during the construction and operation of existing steel plants as a matter of deliberate policy, the dependence on foreign technical assistance will continue and the steel industry will not reach a stage of technical self-reliance. A similar situation exists in almost every other industry."

A number of factors have been mentioned in this article which were emphasized by Bhabha. No single factor was decisive by itself. It was the combination and the inter-relatedness of these factors applied consistently that generated the forces of growth in the institutions with which Bhabha was connected.

GROWTH AND ACTIVITIES OF THE ATOMIC ENERGY COMMISSION OF INDIA

Atomic Energy Commission

Under the terms of the Atomic Energy Act, 1948, an Atomic Energy Commission was set up in August 1948. The Commission which was a policy-making body was assigned the tasks of "surveying the country for atomic minerals, to work and develop such minerals on an industrial scale, to do research in the scientific and technical problems connected with the release of atomic energy for peaceful purposes, to train and develop the necessary scientific and technical personnel for this work and foster fundamental research in nuclear sciences in its own laboratories and in the universities and research institutions in India". The decisions of the Commission were to be

implemented through the Ministry of Natural Resources and Scientific Research.

Dr. Bhabha was appointed the first Chairman of the Commission. Other members were Dr. Bhatnagar, Director General of the Council for Scientific and Industrial Research, and Dr. Krishnan, Director, National Physical Research Laboratory—all eminent scientists and deeply committed to the growth of science and technology in India.

The Commission decided that its first task was to develop scientific personnel that would be needed in future for its activities. It also decided to use existing institutions to do its preliminary scientific work instead of planning at the outset a number of new laboratories. Foremost amongst the institutions used was the Tata Institute of Fundamental Research of which Bhabha was the Director. The early history of atomic energy in India is so closely interwoven with that of the Tata Institute of Fundamental Research, where the early work of atomic energy and of training scientists was done that it has rightly been called "the cradle of India's atomic energy programme". The Tata Institute of Fundamental Research undertook research and later certain administrative responsibilities for the Commission, such as selection of scientists, purchase of equipment and stores, etc.

By 1965 it was felt that research and development in the peaceful uses of atomic energy had made such important strides that a greatly expanded programme would be required. The expanded programme would include producing all the basic materials required for the utilization of atomic energy and the building of atomic power stations for producing electric power. The Government realized that in order to plan and implement the envisaged programme it would have to modify the Constitution of the Commission so as to give it full financial and executive powers. The notification of the Government concerning the organization of the Atomic Energy Commission stated: "These developments call for an organization with full authority to plan and implement the various measures on sound technical and economic principles and free from all non-essential restrictions or needlessly inelastic rules. The special requirements of atomic energy, the newness of the field, the strategic nature of its activities and its international and political significance have to be borne in mind in devising such an organisation."[2]

In 1958, the constitution of the Atomic Energy was amended to provide it with greater powers. The amended constitution stated:

* Department of Atomic Energy Resolution No. 13/7/58-Adm. dated March 1, 1958

"(a) The Commission shall consist of full-time and part-time members and the total number of members shall not be less than three and not more than seven; (b) The Secretary to the Government of India in the Department of Atomic Energy shall be the *ex-officio* Chairman of the Commission; (c) Another full-time member of the Commission shall be the Member for Finance and Administration, who shall also, be *ex-officio* Secretary to the Government of India in the Department of Atomic Energy in financial matters; and *(d)* The Director of the Atomic Energy Establishment, Trombay, shall be the third *ex-officio* full-time member in charge of research and development."

Regarding the Member for Finance and Administration it stated: "The Member for Finance and Administration shall exercise the powers of the Government of India in all financial matters concerning the Department of Atomic Energy. No proposal with financial implications shall be sanctioned without his prior concurrence."

A full-time member for Finance and Administration was included because the idea was that this member would be the chief official in the Department for finance and administration. However, it was soon realized that with the given set-up and nomenclature there was confusion as to the responsibility and accountability of the Chairman-cum-Secretary and the Member for Finance and Administration.

In 1962, the constitution of the Atomic Energy Commission was again amended largely to clarify the role of the Member for Finance in relation to the accountability of the Chairman-cum-Secretary of the Departmeat. The revision provided: "(a) Instead of having a full-time Member for Finance and Administration, one of the members of the Commission was to be the Member for Finance and he was to exercise the powers of the Government of India in financial matters concerning the DAE except insofar as much powers had been or are in future conferred on or delegated to the Department. *(b)* The Chairman could also authorize any member of the Commission to exercise such of his powers and responsibilities as he may decide." Thus, it was amply clarified that the Secretary was responsible for the total administration of the department and that the Finance Member was to advise only on matters not delegated to the Department. It was also considered unnecessary to have a full-time Member for Finance.

The size of the first Commission was three members. With the first amendment, the Member for Finance was added, and later Shri J. R. D. Tata and Dr. Vikram Sarabhai were added. At no time the

Commission consisted of more than five members. In early 1966, the Commission was: Dr. H. J. Bhabha (Chairman), Shri S. Jagannathan (Member for Finance), Shri J. R. D. Tata, Shri Dharam Vira (Cabinet Secretary), and Dr. Vikram A. Sarabhai.

Bhabha being also Director of the Atomic Energy Establishment, Trombay, there was no separate member for Research and Development.

Some important landmarks in the development of Atomic Energy in India are given in Appendix I (p.20).

In reviewing the developments of atomic energy in India, three phases can be identified. The first phase from 1944 to 1954 was the training of scientists, and the starting of scientific groups under the leadership of competent scientist who could, with appropriate facilities and "autonomy of work", develop an excellent work. In this phase, the Tata Institute of Fundamental Research played a significant role.

The second phase could be broadly identified from 1954 to 1962. It marked the growth of the Atomic Energy Establishment at Trombay with emphasis on problems of technology. Three research reactors were built, and simultaneously, the prospecting of atomic minerals was pursued energetically through the Atomic Minerals Division. In this phase, research and development were important leading to pilot plants processing uranium ore, fabricating fuel elements, manufacturing electronic instruments, developing nuclear engineering for reactors, building a plutonium extraction plant, and establishing other facilities at Trombay.

The third phase which commenced around 1962 involved a logical continuation of the earlier development. This phase was the utilization of knowledge and skills acquired. Emphasis was placed on the contribution of the Department of Atomic Energy to economic development through atomic power projects and public sector industries based on the technology developed at Trombay. Trombay was considered a nursery where new developments would be continually nurtured and other sites in the country were identified where know-how and processes could be commercially established.

In the following sections, the role and management system of the Department of Atomic Energy with special reference to the Atomic Energy Establishment at Trombay are outlined.

Department of Atomic Energy

By 1964, the activities of the Commission had so expanded that the Government decided to set up a separate Department of Atomic Energy. The Minister in charge of the Department was the Prime Minister, at that time Shri Jawaharlal Nehru. For administrative convenience and close contacts with the main scientific activities which were in Bombay, the Department's headquarters were located in Bombay instead of Delhi. The Secretary of the Department was also the *ex-officio* Chairman of the Commission.

The research units, projects and other enterprises for which the Department of Atomic Energy was responsible in 1966 are: (1) Atomic Energy Establishment, Trombay; (2) Tarapore Atomic Power Project; (3) Rajasthan Atomic Power Project; (4) Madras Atomic Power Project; (5) Jaduguda Mines Project; (6) Thumba Equatorial Rocket Launching Station; (7) Space Science and Technology Centre; (8) Experimental Satellite Communication Earth Station; (9) Atomic Minerals Division; and (10) Trombay Township Project.

There are a number of institutions which are administratively attached to the Department of Atomic Energy for purposes of receiving grants-in-aid from the Central Government. The institutions falling under this category are: (1) Tata Institute of Fundamental Research; (2) Tata Memorial Hospital, (3) Indian Cancer Research Centre, (4) Physical Research Laboratory, and (5) Saha Institute of Nuclear Physics.

The Indian Rare Earths Limited, a Government Company, is under the administrative control of the Department. Proposals are also afoot to have the following industrial operations converted into public sector undertakings: (1) Electronics Production Unit at Hyderabad, and (2) Jaduguda Uranium Mines & Mill.

The Department has always been of the view that the constituent units of the Department should have wide powers for their day-to-day working. The Heads of these units have, therefore, been declared as Heads of Departments for administrative purposes and in the case of large projects, such as the Atomic Power Stations, apart from the powers delegated to Project Administrators as Head of the Department, fairly wide powers have been given to the Project Boards to enable them to give decisions on all administrative, financial and technical matters arising in connection with the execution of the projects. Only in a few restricted fields, the Boards are required to come up to the Department of Atomic Energy for sanctions.

In order to understand the role of the Department in relation to the units, the process of decision-making, service and control functions, selection and evaluation procedures, are discussed with reference to the Atomic Energy Establishment, Trombay.

Atomic Energy Establishment, Trombay (Bhabha Atomic Research Centre)

In 1954, the Commission decided to set up a separate institution for research and development—the Atomic Energy Establishment Trombay (AEET). To the existing groups for Chemistry and Metallurgy which were operating till then under the Department, were added the scientific groups for theoretical physics, nuclear physics and electronics, which were working on behalf of the Commission at the Tata Institute of Fundamental Research. Along with the scientists were transferred a few administrators to man the newly established Atomic Energy Establishment, Trombay. The number of officers involved in the transfer were about 54. These formed a numerically significant group in the Establishment and hence were able to carry successfully with them a culture appropriate to research and development.

In contrast, the established pattern of setting up new research laboratories was at that time significantly different. Although many of them were created under autonomous organizations, they were started in many cases by a "Planning Officer" seconded by Government. The result was a transfer of culture, but in this case of government administrative practices of recruitment, budgetary controls, purchase of equipment, etc., that were in fact inappropriate to the functioning of a scientific institution. The autonomy that was given to these research institutes was lost to a large extent by the omnibus adoption of Government rules and regulations.

By 1966, the Atomic Energy Establishment, Trombay was the largest scientific centre in the country. It employed a total of about 8,500 persons, of whom approximately 2,000 were professional scientists and engineers, and another 3.000 were technical staff, many of whom are science graduates. The annual budget of the Establishment is about Rs. 11 crores.

For the first few years the main task at Trombay was to provide much of the scientific knowledge and understanding needed to design and construct reactors. The work soon expanded into many fields—atomic fuel, heavy water, radioisotopes, electronic instrumentation and equipment, uranium plant, agriculture, health physics, medical, etc.

The organization structure of the Atomic Energy Establishment, Trombay is given in Appendix II (p. 21) The work is divided into five main research groups and an administration group, all reporting to the Director. The research groups and administrative functions are:

Research Groups	*Administration Groups*
1. Physics	Personnel
2. Metallurgy	Accounts
3. Electronics	Purchase and Stores
4. Engineering	Scientific Information (including Library)
5. Biology	

Within the broad policy formulated by the Atomic Energy Commission, the Director, Atomic Energy Establishment Trombay, is assisted in his scientific and administrative decision-making by the Trombay Council and the Trombay Scientific Committee. The Trombay Scientific Committee consists of the Directors of five major research groups and 25 heads of Divisions. The Committee discusses proposals of research projects from each division, equipment and personnel required in relation to each project, and other related matters. The Committee meets once a fortnight.

The Trombay Council consists of the five Directors of Research Groups and the Administrative Controller. The Director, Atomic Energy Establishment Trombay, is the Chairman of the Council. The Council discusses not only action to be taken arising from current problems, but also forward planning based partly on information from the Chairman and partly on information from the Trombay Scientific Committee. The Council meets once a week.

Within the approved budget and subject to specific approval of capital items in the ways outlined, Trombay has considerable autonomy to manage its own financial affairs. By agreement of the Commission, the Director delegates financial powers up to approved limits to Directors of Research Groups and Divisional heads. Within the overall budget there are divisional budgets.

The Director of the Trombay Establishment is an *ex-officio* Member of the Atomic Energy Commission for Research and Development and has been delegated wide powers. Some idea of the delegated

powers of the Director can be seen from the following: *(i)* Reappropriation of funds under the Revenue Grant, *(ii)* Creation of temporary posts up to a salary of Rs. 2,000/- p.m., *(iii)* Granting higher starting pay and grant of advance increments, *(iv)* Sanction contingent expenditure after consultation with the internal finance adviser regarding availability of funds, and (v) Write off losses up to Rs. 25,000 in respect of stores. The Director can delegate his powers to any authority subordinate to him.

The problem of consultation, communication and control between the Atomic Energy Commission and the Atomic Energy Establishment Trombay was relatively simple since Bhabha was the Chairman of the Commission, Secretary of the Department, and Director of Atomic Energy Establishment. Projects which were approved at the Trombay Scientific Committee and the Trombay Council were assured simultaneously the sanction of the Department and the Commission because of Bhabha's common role. In such a situation, the role of administration in the Secretariat became one of service rather than of control. The Department assisted in getting the necessary equipment, stores, foreign exchange, etc., for carrying out projects.

Great care was given to the selection, training, development and appraisal of staff. In general, the policy was to recruit young science graduates, train and develop them within the Establishment. In order to meet the growing requirements for suitable scientific personnel a Training Institute was started in 1957. Selections are made on the basis of recommendations of duly constituted selection committees with elaborate selection procedures. Experts from universities and industry are invited to serve on these selection committees. Applications from science and engineering graduates with first and second class degrees are invited. Each selected candidate is given a stipend of Rs. 300/- per month. The faculty of the Training School is partly from the Atomic Energy Establishment Trombay and partly from the Tata Institute of Fundamental Research. In 1965, about 3,400 applications with first and second class degrees were received. Out of these 251 were selected on the basis of an interview—130 actually joined the school, and 125 completed the course and were appointed at Atomic Energy Establishment Trombay and in other units of the Department. About these young trainees, Bhabha said, "at the end of two to three years they become very useful scientists. The best among them are likely to become future leaders. We have found this method of recruitment very satisfactory, and although it has placed a heavy load on our senior staff by making the spectrum of our scientific staff much heavier at the junior levels than as it should be, it has provided a

powerful source of able young scientists on the basis of which the programme can be expanded continuously in future."[3]

The evaluation procedures at the Atomic Energy Establishment Trombay are the same as those evolved by Bhabha at Tata Institute of Fundamental Research. In evaluating a research worker's performance the first step is for the research worker to write his own report about his past performance in relation to the tasks set, mentioning any special accomplishments or problems. This report is then processed independently by two other assessors. The total report is then forwarded to the Director with recommendations for increments or promotions. Promotions from one grade to another are made not on the basis of vacancies, but on the development and worth of the individual research worker.

Bhabha was the Director of the Atomic Energy Establishment Trombay as well as of the Tata Institute of Fundamental Research. Practices and procedures "innovated" at the Tata Institute of Fundamental Research were used at the Atomic Energy Establishment Trombay, so that tested administrative practices appropriate to research and developmental tasks were introduced within a government organization.

SOME IMPLICATIONS

The question arose "Why did it happen? Are the experiences drawn from the growth of atomic energy in India translatable to other institutions and fields?" In the account we have presented, we cannot help noting a remarkable coming together of people and events: Independent India led by Jawaharlal Nehru who believed in transforming the nation through the application of science; Bhabha, a sophisticated engineer-cum-theoretical physicist who enjoyed the confidence of Nehru and possessed a wide international reputation and contacts; the exploding of the atom bomb over Hiroshima and Nagasaki which led to an unprecedented nuclear arms race under conditions of great secrecy; a horrified world eager to promote the peaceful uses of the atom and thereby coping with the guilt arising from ruthless military preparations; the release of scientific and technological know-how on an unprecedented scale following the first Atoms for Peace Conference in 1954, making available to countries, such as India, basic data which in other areas of economic significance could be purchased only at great cost. But if the ecology

[3] **S. N. Gupta (Ed.),** ***Ten Years of Atomic Energy in India, 1954-64,*** **Bombay, Times of India Press.**

and the factors for growth were ripe to make possible what has been described in this article, there is nevertheless a lesson in the story, which has significance in a much wider context. The following is a summary of what are believed to be factors contributing to the success of atomic energy in India and it is hoped that some useful guidelines will emerge, on the one hand, for policy makers concerned with developing institutions and organizations and, on the other hand, for organizational structures and administrative practices relevant wherever developmental tasks are to be undertaken:

(1) The concern, care and nurture of people who have knowledge and skills conveyed to them a sense of trust and the significance of their role in building society. Bhabha received all these from Shri J. R. D. Tata and Prime Minister Nehru, and in turn, gave it to the young scientists and engineers who came to work with him.

When Bhabha returned to India during World War II the Dorab Tata Trust created a Chair for him at the Institute of Science, Bangalore, so that he would have the freedom and facilities to do research. Later in 1944, when Bhabha wrote to Shri J. R. D. Tata suggesting an Institute for fundamental research in physics and mathematics, the Tatas accepted the proposal and the financial responsibility for such an idea. It is significant to note that the Tatas supported the idea at a time when nuclear physics had not become the "bandwagon" of science and more than a year before the explosion of the first atom bomb in Hiroshima. Also as Bhabha pointed out at a time "before it had been made public that atomic piles had been successfully operated and long before there was any talk of atomic power stations".

Bhabha also received support and understanding to an unusual degree from Prime Minister Nehru. Both men saw the essential role of science in transforming not only the economy of the country but transforming man. Nehru believed that if India was to be transformed from an industrially underdeveloped to a developed country, it was essential to establish science as a live and vital force in society. Nehru was the President of the Council for Scientific and Industrial Research, and later when the Department of Atomic Energy was established, he became the Minister in charge of the Department.

As mentioned earlier, Bhabha's approach to building institutions was to build the organization around men. No organization chart stood in the way of recognizing and rewarding talent. The Apsara reactor was built almost entirely by Indian scientists and engineers. He conveved confidence in the ability of men and the men usually

rose to the occasion. Bhabha "protected" his scientists from bureaucratic procedures and organized administration largely as a service rather than a control function.

(2) The combination of policy-making, executive and scientific roles provided the Chief Executive, power, freedom and authority which were important. Bhabha was the Chairman of the Atomic Energy Commission, the Secretary of the Department of Atomic Energy, the Director of Atomic Energy Establishment Trombay, and Director of the Tata Institute of Fundamental Research. The combination of these four roles provided the Chief Executive with sufficient freedom and flexibility in decision making and commitment of resources. It also meant that the Chief Executive had powers and responsibilities which permitted full accountability.

The combination of these roles also meant that Bhabha was able to keep his "grass-roots" in scientific research. It was this facility of working as a policy maker, organizer and administrator on the one hand, and participating in the scientific work at the "coalface" level on the other hand that provided him the on-going understanding to motivate and manage his research workers. In research laboratories, and in other developmental tasks it seems important that the Chief Executive, besides policy-making and administration, maintain 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.

(3) 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, procedures and practices in the organization. The numbers should be large enough to achieve a critical size to permit positive interactions.

The establishment of research groups and the development of second generation scientists in the Tata Institute of Fundamental Research and in the Chemistry and Metallurgy Groups of the Commission preceded the setting up of the Atomic Energy Establishment at Trombay by about ten years. This transfer of a large group rather than a few individuals was significant in terms of the "culture" and success at the Atomic Energy Establishment, Trombay. In this connection, it is often necessary to spin off new institutions from existing ones transferring not only expertise but a social culture appropriate to the task.

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 organizations or in industrial enterprises is very questionable. Even though many of these organizations are established as autonomous in the legal sense, administrative practices are introduced which negates the formal autonomy granted. The existing government procedures of selection, promotion, evaluation, budgetary controls, buying of supplies and equipment are highly inappropriate to the effective functioning of scientific laboratories and industries involving complex technologies. In other words, conditions have to be created through the selection of appropriate men and through association with a mother organization to ensure that the formal and administrative cultures support each other for the fulfilment of the task.

(4) In professional groups, scientists, engineers and others, it is important to recognize that motivation and control is largely inherent and contained in professional commitments. In organizations 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.

In the Atomic Energy Establishment, Trombay and other units administratively connected with the Department of Atomic Energy, the organization structure and procedures were those of decentralization. There was a minimum organization structure and formal control. Even though there was a hierarchical structure, because of the nature of work it was not used as a means of communication and decision-making.

Within the broad policy set, research groups discussed and defined their objectives and targets. When research projects were approved, associated with it was approval for budgets, equipment and manpower. Budgetary and other controls were self-contained in the formulation of projects. This again re-emphasized the role of administration as facilitation of work rather than outside control. The need to control is almost an inevitable psychological product of the structured field of which bureaucratic organizations are an example. With the devaluation of hierarchical authority and positional status in scientific work, mechanisms of administrative control were also devaluated. Control was exercised through discussion and judgment of peers.

(5) 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.

The number and membership of the Atomic Energy Commission were important factors in setting the "tone" and "quality" of meetings and the policy decisions taken there. As mentioned earlier, the members of the first Commission were Dr. Bhabha, Chairman, Dr Shantiswarup Bhatnagar and Dr. Krishnan, Director of the National Physical Laboratory. When the Department of Atomic Energy was established, a member for Finance and Shri J. R. D. Tata were added as members. Subsequently, Dr. Vikram Sarabhai was invited to be a Commission member. The Commission consisted of 5 to 6 members (The Board of the C.S.I.R. at present consists of 34 members), all significantly able to contribute to policy making regarding nuclear energy and its development in India.

(6) There is a need for a constant interplay between the basic sciences, technology and industrial practice of economic progress is to result from the activity undertaken. The wearing of several hats by the same person, as in the case of Bhabha and the mobility of per sonnel 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 has to be done through other units, not organically related to the laboratories or the men that work in them.

(7) The conditions under which scientists and professional workers are motivated are somewhat different from those who work in bureaucratic or industrial enterprises. 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-deve lopment are also important factors.

Bhabha's philosophy was to identify the right persons, and then give them all the autonomy and support they wanted within the broad objectives. As mentioned earlier, these were also Bhabha's needs which were supported by Nehru and Tata.

There were a number of research institutions administratively connected with the Department of Atomic Energy—the Tata Institute

of Fundamental Research, the Saha Institute of Nuclear Research, the Physical Research Laboratory at Ahmedabad, and other educational institutions. This loose federation of institutions provided a unique opportunity to the scientists of sharing experiences and information. Bhabha also encouraged and sponsored his scientists to attend international meetings. The opportunity of meeting scientists who came from abroad, of sharing facilities, of attending meetings and symposia provided by intellectual environment, which would have been difficult to provide by any single institution. The relative autonomy, the mobility and interaction of scientists and engineers nationally and internationally were important factors in the motivation and morale of these people.

CONCLUSION

In this story of the phenomenal growth of atomic energy in India, it has been attempted to identify some factors which facilitated growth. By implication it is also possible to discern factors which are unhelpful and inhibit development. The various factors indicated earlier are interrelated and mutually dependent. A change in one influences the total scheme of things, for in organizational 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 nurture on the part of responsible persons. There is need to understand that there is a shift from simple to complex technologies, from stability to innovation, from experience-based knowledge and skills to highly conceptual knowledge. The understanding of this change means the recognition of socio-technical systems rather than a mechanistic organization structure, the recognition that highly trained and professional groups have different needs and motivations, the realization that hierarchical structures and systems need to be minimized and that the concept of control is inherent and contained in professional commitments rather than exercised from outside.

APPENDIX I

Some Important Landmarks in the Development of Atomic Energy in India

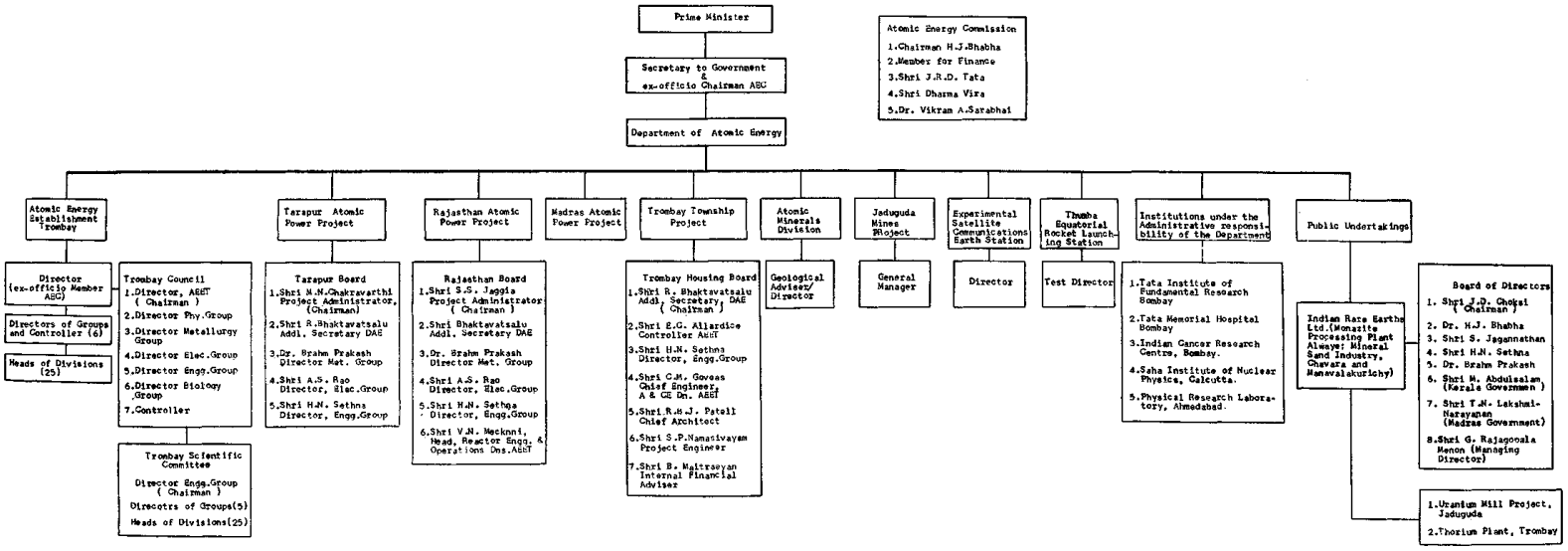
1945	April	Tata Institute of Fundamental Research
1948	April	Atomic Energy Act of 1948 received assent of Governor General
	August	Atomic Energy Commission set up
1950	August	Indian Rare Earths registered as a limited company

1954	January	AEC decides to set up Atomic Energy Establishment, Trombay
	August	Department of Atomic Energy created
1955	March	AEC decides to build Apsara reactor
	August	First U.N International Conference on the Peaceful Uses of Atomic Energy opens in Geneva under the presidentship of Dr. Bhabha
1956	February	Work on CIR reactor with Canadian assistance Radiochemistry Laboratory set up
	May	Decision to set up Uranium Metal Plant and Fuel Element Fabrication Facility
	October	Travancore Minerals Ltd. registered as a limited company
1957	August	Training School started
1958	March	Constitution of AEC revised
	June	AEC reconstituted
	July	Decision to build Plutonium Plant
	August	Planning Commission approves the building of India's first atomic power station at Tarapur
1960	February	AEC decides to build Uranium Ore Mill at Jaduguda
	May	Erection of Zerlina reactor begins
	September	Heavy Water Reconcentration Plant commissioned
1962	February	Administrative responsibility for Indian Cancer Research Centre and Tata Memorial Hospital both at Bombay transferred to the Department to facilitate rapid development and expansion of medical facilities and research in cancer and other diseases with the help of isotopes, etc. Indian National Committee for Space Research constituted.
	March	Constitution of AEC further amended
	August	Decision to build second atomic power station at Rana Pratap Sagar, Rajasthan
	September	Atomic Energy Act, 1962 comes in force
	December	Kalpakkam selected as site for third atomic power plant
1964	January	Six more rockets launched from Thumba
	July	Three meteorological rockets launched from Thumba
	November	Three Nike-Apache rockets launched from Thumba in the international synoptic launching series.

APPENDIX II

ORGANIZATION AND STRUCTURE OF ATOMIC ENERGY COMMISSION, TROMBAY

As on January 1, 1966



ATOMIC ENERGY COMMISSION

Implications of large atomic power stations as sources of low cost energy in India

by
VIKRAM SARABHAI Chairman,
Atomic Energy Commission

The cost of power generation in India, except in large hydro installations, generally exceeds 5 Ps per KWH. In many areas indeed it is 25 to 50 per cent higher. The cost of atomic power, as for example, at Tarapur, would be fully competitive with energy produced from fossil fuels. Currently, the only inexpensive sources of electric power are the large hydro electric generating units, but these are tied to very specific locations in the country and their benefits do not reach other parts of the country.

We should compare the level at which power is currently produced in India with conditions existing in industrially advanced countries. There the cost of production of electricity is approximately half of that in cur most advanced fossil fuel power stations. The implications to our national economy, of a state of affairs, in which primary energy costs about twice as much as the cost at which advanced nations can generate electricity, can be truly staggering. They do not arise only from a consideration of the proportionate cost of energy in the total cost of a product. The effect is not only cumulative, but can have a major impact on the whole pattern of growth and development involving alternative technologies for producing the same product. It is well known, for example, that nitrogenous fertilisers can be made from ammonia derived either from Naphtha, natural gas or from the electrolysis of water. While Naphtha or natural gas are available in certain areas, factories for nigrogenous fertilisers using inexpensive electricity from large atomic power plants can be located in any area. Imports of sulphur can be avoided if the phosphorus for fertilisers is produced electrolytically using low cost energy.

Perhaps the most important factor for the difference in costs for generating electricity in developing nations and in industrially advanced nations arises from economies resulting from the scale of operation. Inherently, a developing nation starts with a low base of energy requirement and even if its economy doubles itself, in say five years, the incremental growth of power is quite small and does not justify in the normal course of events, the establishment of large generating station with single units of 500 to 1000 Mega Watts. This aspect of the problem is surely relevant to a remarkable feature of the post-war period, where the gap between developing nations and the advanced nations has widened, not narrowed.

Table 1 which gives the installed capacity for 1966-67 of the major grids in this country clearly demonstrates the problem we face due to the relatively small size of our existing grids in relation to a single generating

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unit of 1000 MW. It is noteworthy that the establishment of the atomic power station at Tarapur will be the occasion for the interconnection between the Gujarat and the Maharashtra grids. Indeed we have here an example that the whole is much greater than the sum of its parts, and that inter-dependence is more rewarding than self-sufficiency.

Planning for the establishment of future atomic energy power stations beyond the three (Tarapur, Kotah and Madras) where construction is already going on, is a matter of great importance to the Indian Atomic Energy Commission. Due to the dramatically low cost of power generation that results from the installation of large size nuclear power stations, it is very relevant to examine whether there is any way by which one can establish single units of large size and provide inexpensive energy which could really revolutionise the economic development of many areas in the country. This, of course, means that one has to change one's entire approach to the problem of establishing electricity generating stations. Traditionally, one forecasts the growth of load and establishes generating capacity to meet the load. But we can take a different approach. We can plan for an integrated complex which involves both generating capacity as well as a major consuming centre right alongside the generating unit. The energy consuming centre would provide the requisite base load at a minimum of transmission cost. The grid would be fed only with the surplus which can then be sold at a much cheaper rate than would otherwise be the case. The feasibility of this new approach is vitally dependent on the technological and economic evaluation of the consuming centres which can be put up alongside large low cost energy units. The prospects of building in India large size atomic power stations following the Madras Station, of the fall out to Indian industry and agriculture resulting from such a programme and, above all, of increasing food production by 5 to 7 million tons using outputs of an agro-industrial complex around a large atomic power station, are so exciting as to require clear headed analysis based on facts pertaining to local situations. The Indian Atomic Energy Commission has therefore established a Working Group to examine this aspect in different regions of the country.

The problem that faces India in regard to the establishment of inexpensive energy sources is of course common to almost all developing countries and to many advanced countries as well. The Oak Ridge National Laboratory of the United States Atomic Energy Commission has conducted studies over several years on the technological processes which can be applied to produce from low cost energy sources fertilisers and other materials necessary for an agro-industrial economy. Last summer, engineers nominated by the Indian Atomic Energy Commission participated in a study group at Cak Ridge. Several of the American specialists from the U.S. Study Group will be visiting this country during the next few weeks to discuss the studies being made by the Indian Atomic Energy Commission. The studies relate not to the generation of nuclear power, but to the use of low cost energy and its impact on the development of the economy, particularly agricultural production in different regions, where there is scope for great improvement.

TABLE I

SIZE OF MAJOR GRIDS
(Figures for 1966-67)

		Capacity in MWe
1.	South Bihar) Lower Bengal)	2424
2.	Gujarat Power System	619
3.	Kerala Power System	547
4.	Madras Power System	1540
5.	Maharashtra Power System: Tata - Central Rly. - Koyna	1307
6.	Mysore Power System	702
7.	Hirakud	526
8.	Bhakra Nangal	1208
9.	U.P. Power System	1405

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11/11/1967.

SCIENCE AND NATIONAL GOALS *

BY

Vikram Sarabhai Chairman,
Atomic Energy Commission.

The Science Policy Resolution of 1958 of the Govt. of India** illuminates clearly and concisely the relationship of science and national goals. And yet, more than ten years later, most of us are largely dissatisfied with the role that science is currently playing in promoting national goals. What is the problem?

Our national goals involve leap frogging from a state of economic backwardness and social disabilities, attempting to achieve in a few decades a change which has historically taken centuries in other lands. This involves innovation at all levels. It was not until I was made responsible for the Atomic Energy programme of this country and came face to face with problems of development through the application of advanced technologies and basic research, that I became conscious of the problems that are encountered when Government has to perform a role which goes much beyond the maintenance of law and order and the security of the nation.

* Part of the material contained in this article was included in the Convocation Address delivered at the Indian Institute of Management, Ahmedabad, in April, 1967.

** It is worthwhile to refer to the document, and I therefore reproduce it as an annexure.

I recognise that governments are involved in providing stability as well as change to society, two seemingly conflicting goals. 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. We would have near disaster if we have a judge who *is* an 'innovator' instead of a 'preserver'. On the other hand, an educational or a scientific administrator would be sterile and ineffective if he is a. preserver rather than an innovator. Most tasks encountered in the contemporary world call for organisations wherein creative thinking and innovation are essential ingredients of survival as well as growth. Industrial and agricultural development, and the conduct of foreign affairs call for innovators, rather than traditional administrators.

It is perhaps useful to note that if in a given situation we are content to leave all environmental conditions unchanged, we can at best achieve an evolutionary change through the natural course of survival and growth. On the other hand, forcing the pace of development needs probing the

boundary conditions of each situation so as to push in the direction in which change is possible. The instruments of change have therefore to be those who do not take their environment for granted.

Most of us are familiar with the hierarchical organisation structures involving vertical controls which continue to dominate governments whose principal role until recently was one of preserving a social order. They carry an administrative service, characterised by anonymity coupled with security of tenure, insulating individuals from outside pressures. The system has built in controls which act negatively, attempting to stop a wrong thing from happening.

To realise how distant this culture is from one wherein innovators are involved in developmental tasks, we can examine some of the factors which have been observed in the study of Atomic Energy. Organisations were built round men, and no organisation chart stood in the way of recognising and rewarding talent. Amongst professional groups of scientists and engineers, motivation and contral was largely inherent and contained in professional commitments. Control was exercised through discussion and judgment of peers with administration performing largely the role of service. Autonomy of working conditions and self-development were important to the innovators. Horizontal control systems are effective when they involve mobility and interactions. The economic analogue of horizontal controls is competition. Horizontal controls are implicit and do not have to be imposed

from above. For instance, if there is a situation where supply exceeds demand, the price is controlled by competition rather than by price control. Each competitor, without having to be told so, fully realises the negative implications of his charging a higher price than others. The military application of it is seen in arms control through the balance of terror. Armed conflict between the U.S. and the U.S.S.R. during the last twenty years has been prevented not by action of the United Nations, but by the implicit threat of reprisals.

While vertical controls are dependent on a system of reporting and feed-back involving more than one level horizontal controls are dependent on direct interaction at the same level. The 'hot line' between Moscow and Washington is necessary to preserve stability through horizontal controls between the two power blocs. The effectiveness of vertical controls are dependent on the time span of delegation. For instance, if the Public Accounts Committee reviews the operation of a Government undertaking two to three years after an event has occurred, its comments cannot have any possible effect in producing control on tactical decisions by the management. With a time span of this order only a strategic decision such as one involving the establishment of a steel plant could be questioned with relevance to controls.

One may ask why competition which is synonymous with horizontal controls has become associated with capitalism? Are horizontal controls contrary to socialism or the State ownership of the means of production? Would it hurt if

Hindustan Steel were not just one company? Would not the managements of Bhilai and Durgapur have positive incentives if they were competing with each other and with TISCO and Indian Iron? Can vertical controls of a Board of a monolithic corporation or of the Bureau of Public Enterprises, or of the Parliamentary Committee on Public Enterprises, or the Auditor General provide adequate substitutes for what can be gained through accountability for task performance in a situation of survival and growth in a competitive economy? Vertical controls usually specify what cannot be done. The Industries Development and Regulation Act is a typical example of such control. Top bodies involved in such control can rarely function in anything but roles of strategic decision making. When they involve themselves in the decision making processes of day to day administration, the system indeed gets fouled up. I would suggest that since vertical controls inhibit innovation and remove the decision making process from the operating level, they are unsuitable as a system for the developmental tasks of government.

We are not suggesting here the abdication of supreme authority at the top most echelon of government. But one is talking of a self-restraint and exercise of power based on understanding of the control systems appropriate to developmental functions. One is moreover asking for a sophistication which recognises that there is a distinction between *a* formal and a real organisational structure, the social culture of an organisation being influenced mainly by the men who are in it, the determining factors being their assumptions and outlook

on life and their attitudes related to their past training and traditions. It is because of this that one despairs of finding solution to our real problem by only organisational changes.

In research laboratories, and in other developmental tasks, it seems important that the Chief Executive, besides being involved in policy making and administration, maintains 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.

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 Deptt. 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.

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.

With the problems that we are facing in the country today, it is pertinent to ask how the considerations which we have discussed are relevant to Government. The foremost need would be to identify activities where developmental functions are primarily involved. Organisational reforms involving systems of horizontal and vertical controls would grow naturally when men who are appropriate for these tasks are placed in positions of responsibility. Will we have the conviction and courage to introduce these changes? The answer is surely crucially related to our survival.

We have today in India an excellent infra-structure for undertaking complex tasks involving science and technology for resolving the real problems of the nation in the production of food, for industrial development, energy resources, communications and transportation. We can make a qualitative difference in the educational system through the use of new techniques of learning and we are rich in our human resources. It is now clearly necessary to translate the broad national goals into precise objectives to be realised in two, five and ten years. Using techniques of systems engineering and operations research, we have to determine in each case the most advantageous route to follow, and decision making must be related to quantitative analysis of all factors and inputs, to permit a commitment which is based on what we wish to consciously achieve paying a well understood price.

We *often* hear in this country talk of a science budget. This would be relevant only if we were pursuing science for its own sake. What are needed, however, are the priorities for broad national goals and, dependent on these to determine what effort in science and technology is called for to achieve these goals. Thus, the priority for scientific effort in a particular are? follows from the priority enjoyed by the area in question in the overall scheme of things in our National Plan. We might, for instance, give top priority to the production and distribution of energy inexpensively to promote agricultural and industrial development. We know that the doubling time of our electricity consumption is about five years and therefore we would need during the next ten years to have a. minimum of about 40,000 MW of additional power generation to maintain even a reasonable level of economic growth. At a cost of about Rs.2,000 per installed KW, this would need an investment, for generation alone, of approximately Rs.8,000 crores in ten years. If we wish to provide the most economical solution with the largest amount of import substitution, it would be reasonable to spend at least 5 per cent on indigenous R & D for improving technology and for developing indigenous capability for design and development. Thus, the expenditure on specific schemes of R & D related to the generation of power could well be about Rs.400 crores in the next ten years. I give this example to illustrate the manner in which we can derive an estimate of the required effort in each individual specific

area in order to reach a specific goal. It is only when we have analysis of this type that we shall be able to move ahead with confidence with our scientific and technological effort to realise the objectives of the Scientific Policy Resolution. Without it, we shall foster neither science nor realise our national goals.

October 1969.

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Annexure

GOVERNMENT OF INDIA
SCIENTIFIC POLICY RESOLUTION

New Delhi, 4th March 1958.

The key to national prosperity, apart from the spirit of 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 replication of a welfare state differs widely from country to country in direct relation to the extent of industrialisation and the effect 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 manpower 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 technology in the form of plant and machinery, highly paid personnel and technical consultants. *An* early end 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 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.

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

(i) to foster, promote and sustain, by 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 full 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 academic freedom; and

(vi) 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.

NR:

AN AGRO-INDUSTRIAL COMPLEX IN THE GANGETIC PLAIN*

By

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M.S. Kumra, C.M. Shah, R.K. Verma, V.B.Godse

1. INTRODUCTION

In terms of a per capita power consumption of 66.17 Kwh/annum India occupies the 113th position in the world. However, because of her sheer size India today is in a unique position to utilise the benefits of atomic power. With an installed power generating capacity of 9700 MWe in 1966 it had the 14th largest power system in the world. Moreover, among the developing countries, as can be seen from Table 1, India has the largest power system. Since its doubling time is about seven years, and any decision concerning new generating plant taken now should be in relation to its size by 1975, we have to consider a national figure of about 25000 MW made up of four regional grids of about 6000 MW each. Because of this, India has options in regard to the size of its power stations and technologies adopted, which are not generally available to developing countries.

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* Paper presented by Dr. Vikram Sarabhai, Chairman, Atomic Energy Commission, at "the Seminar on Nuclear Power, Bombay, January 1970" on January 17, 1970.

The cost of power generation in India except in large hydro installations, generally exceeds 5 Ps per KWH. In many areas indeed it is 25 to 50 per cent higher. While atomic power, as for example, at Tarapur, is less expensive than energy produced from coal fired stations more than 500 miles from pithead, currently, the only inexpensive sources of electric power are the large hydro electric generating units. These are, however, most economical for peaking purposes and are tied to very specific locations in the country and their benefits do not reach other parts of the country.

We should compare the level at which power is currently produced in India with conditions existing in industrially advanced countries. There the cost of production of electricity is approximately half of that in our most advanced fossil fuel power stations. The implications to our national economy, of a state of affairs, in which primary energy costs about twice as much as the cost at which advanced nations can generate electricity, can be truly staggering. They do not arise merely from a consideration of the proportionate cost of energy in the total cost of aproduct. The effect is not only cumulative, but can have a major impact on the whole pattern of growth and development involving alternative technologies for producing the same product. It is well known, for example, that nitrogenous fertilisers can be made from ammonia derived either from Naphtha, natural gas, low grade coal or from the electrolysis of water. While the first three are available in certain areas and impose economic penalties when transported over long distances, factories for nitrogenous fertilisers using electrolytic hydrogen produced with inexpensive electricity from large atomic power plants can be located in any area. Imports of sulphur can be avoided if the phosphorus for fertilisers is produced by electrothermal reduction using low cost energy.

Perhaps the most important factor for the difference in costs for generating electricity in developing nations and in industrially advanced nations arises from economies resulting from the scale of operations. Due to the dramatically low cost of power generation that results from the installation of large size nuclear power stations, it is very relevant to examine whether there is any way by which one can establish single units of large size and provide inexpensive energy which could really revolutionise the economic development of many areas in the country. We can plan for an integrated complex which involves both generating capacity as well as a major consuming centre right along side the generating unit. The energy consuming centre could provide the requisite base load at a minimum of transmission cost. The grid could be fed only with the surplus which can then be sold at a much cheaper rate than would otherwise be the case.

The preliminary findings of our study as to how low cost nuclear energy can be used for the production of nitrogenous and phosphatic fertilisers, for the production of aluminium, for providing water for irrigation either by desalination or by energising tubewells and ultimately for cultivating food crops were presented last year*. In view of the major impact which can be made on a well populated, but economically depressed area of the country, we have now made a detailed examination of the existing conditions in three divisions of Western Uttar Pradesh, and the specific initiatives that could be taken from amongst alternative choices. We have been fortunate in receiving close cooperation from officials of the Uttar Pradesh State Government and concerned central Ministries as well as specialists of the U.S. AEC. In the micro-study which we describe, we examined factors which we believe to be of vital importance to the success of the project such as logistics of storage *

AEC Monograph 1, 1069, "Nuclear Power in Developing Countries."

and movement of large quantities of materials in and out of the complex, and the problems of management which were not covered in our preliminary report.

II. POWER COSTS AND AGRICULTURAL ECONOMICS IN WESTERN U.P.

The project proposed for Western U.P. is based on nuclear power to produce fertilisers and supply energy for tubewells for irrigation. Water from tubewells, though cheaper than desalted water, is more expensive than surface water. Its cost ranges from 10 Paise to 25 Paise per 1000 gallons for power cost from 5 Paise per KWh to 30 Paise per KWh respectively. At 15 Paise per KWh paid by the farmer for power, energy would represent approximately 50% of the total cost of water. In recent years, using high yielding varieties of seeds, the capacity of the farmer to pay for power has increased. On the other hand when power can be produced at a lower cost than before, the benefit of such lowering of cost should go first to those consumers, who need it most and whose economy is critically dependent on power cost, such as the power consuming industrial units. In order to determine a differential tariff system it is necessary to know the power cost tolerance of agriculture. Moreover, whereas the construction and commissioning of a nuclenr power station may take about five years, agricultural schemes could be implemented much faster if we could provide an interim source of power. Such power may not be inexpensive and hence it is necessary to know the maximum permissible tariff for power which could still benefit the agriculturist.

The influence of the cost of power on the economics of cultivation of various crops and crop rotations has been studied. Fig. 1 gives the estimated cost of production of various agricultural products using bullock power and mechanical appliances. In Fig.2 the net profit for various crops has been plotted. The figures are valid in the case of moong and wheat when they are cultivated as part of a three crop rotation viz. bajra-wheat-

Sugarcane *is* of course nn annual crop. The cost of production should be significantly below the market price to give an attractive return to the farmer and to induce him to make the necessary investment. It can he seen that the returns from the farm are quite attractive at a power cost of 15 p/KWh (assumed power tariff for agriculture in the project) or even at 25 p/KWh which is the maximum anticipated cost of power from an interim source such as a gas turbine.

ESTIMATE OF GROUND WATER POTENTIAL OF WESTERN U.P.

The total annum pumpage of underground water in western U.P. at present is only approximately 5.2 million acre feet. The total area proposed to be covered under the Agro-Industrial Complex is 1.5 million hectares (3.75 million acres). In order to have a 300% intensity of cropping (three crop rotations) over this area, annual water requirement for irrigation will be 13.22 million acre ft. (Appendix 1). As stated earlier the main basis for identyfying Western U.P. for the project is the availability of underground water in sufficient quantity for intensive cultivation with two and three crop rotations. There are grounds to assert that this assumption is reasonable. However, for a precise and quantitative estimate of the under-ground water and in order to ascertain the rate of recharging of the aquifers a series of experiments have been planned jointly by the Bhabha Atomic Research Centre, the Tata Institute of Fundamental Research and the U.P. State Government.

(a) The determination of aquifer conditions e.g. thickness, depth, inter-connections and water content in the aquifer (porosity), will be made using existing strata charts and spring levels and from data collected by drilling bore wells and preparing geological correlation logs. Electrical logging of these wells may confirm the nature of the aquifer horizons and finally pumping tests should determine the aquifer characteristics.

(b) study would be conducted of the seasonal changes affecting the movement of ground water and of recharging of the aquifers first, due to rain, second due to charge and discharge through streams, canals and rivers, and third from new projects for storage of water. This will be accomplished by injecting radioactive tritium as a tracer into the soil and studying its movement due to percolation of rain water, and also by noting the rate and direction of movement of underground water by injecting tracers in the observation wells.

The radioactive tracer studies for the determination of rain water percolation and direction of movement of water would be undertaken by BARC and TIFR while the field observations and drilling of bore wells and field tests are expected to be carried out by the U.P. State Government. The entire data thus collected would be assessed to confirm the estimated availability of underground water for requirements of the proposed Agro-Industrial Complex.

IV. DESCRIPTION OF FULL COMPLEX

Fig.3 shows the area covered under the complex. It consists of the three Western Divisions of Agra, Meerut and Rohilkhand in U.P. Based on an irrigation potential estimated above, the project details are described in Fig.4. The complex involves a power station with two nuclear reactors each of 600 MWe capacity. Fertiliser plants of total capacity of 1.2 million tonnes per annum and an aluminium plant of 50,000 tonnes per annum are also envisaged. The agricultural part of the scheme consists of 12,950 shallow tubewells of 0.5 cusec capacity each and 12,850 deep tubewells of 1.5 cusec each. Approximately, 300 MWe will be needed to energise the tubewells. A summary of the salient features of the agricultural part of the project is given in Table 2. Approximately 1,500,000 hectares are proposed to be irrigated. The incremental agricultural production will be 22.82 million tonnes made up of 7.8 million tonnes of cereals, 1.7 million tonnes of pulses,

.35 million tonnes of oil seeds and 13 million tonnes of cash crops (sugarcane, potato and cotton). Table 3 gives the balance sheet of a typical farm. The net income from the farm works out to Rs.4810 per hectare with mechanised farming. With bullock farming, the income would be Rs.4271 per hectare.

140 million man days of labour are involved in mechanised farming and 470 million with bullock fanning. This is equivalent to an all the year round employment at the rate of 330 days per year of about 5 million persons for mechanised farming and about 1.4 million persons for bullock farming. At the present time, since the intensity of farming is less than 150 per cent in the area, the gainful employment at best is at about half of these figures and is merely at a subsistence level to a large fraction of the population. The average annual income of each worker so employed would be about Rs. 2,100 and the net profit which has been computed is after providing for all wages.

The total investment on the Industrial Complex is about Rs. 425 crores (US $ 567 million). Table 4 shows that the return on this investment should be about 14.39 per cent. In arriving at this evaluation differential tariff rates of 2.8 Paise per KWh for fertilisers, 2.0 Paise per KWh for aluminium and 15 Paise per KWh for tubewells involving a realisation of 8.5 Paise per KWh for the nuclear power station have been assumed. Though the power cost for tubewells is higher than for industry, the suggested rate is comparable to the existing tariff in the region and, as was shown in Table 3, it still provides a profit of about Rs.4,200 - 4,800 per hectare to the agriculturist.

Another alternative available to us with regard to fertiliser production depends on ammonia, obtained via electrolytic hydrogen, being oxidised to nitric acid which in turn is used to acidulate phosphate rock to give nitric

phosphate. As shown in Table 5. capital investment required for such a scheme is Rs.410 crores. The operating costs and profits of the scheme are given in Table 6. The return on investment in this case is 17.27 per cent, which is more than that for the scheme involving ammonium nitrate and diammonium phosphate. There is, however, uncertainty about the acceptability of nitric phosphate for use as a fertiliser on a large scale and consequently this alternative may be difficult to adopt at present without extensive trials and promotional activity.

Apart from the return on the individual units of the complex, it is of interest to examine the economics of the scheme on an overall basis as Riven in Table 7. The total investments with mechanised forming will be Rs.1,232.4 crores and with bullock farming Rs.1,167.8 crores. Table 8 gives the overall operating expenses. The cumulative annual expenses amount to Rs.420.2 crores, with mechanised forming and Rs.527.5 with bullock farming. As shown in Table 9, we estimate an overall return of 68.1 per cent on incremental invested capital in the project with mechanised farming and 62.2 per cent with bullock farming. There is no doubt that these are high enough to make the new investment an attractive proposition and one which should be undertaken with urgency.

V. DISCRIPTION OF A "LIMITED" COMPLEX UTILISING IMMEDIATELY AVAILABLE TECHNOLOGIES.

The full complex envisaged in the earlier section makes several assumptions. The most important of these are:

1) The feasibility of constructing in India, with largely Indian manufactured hardware and utilising nntural uranium as fuel, a reactor of unit size of 600 MWe at a capital cost of about Rs.2000 per KW.

2) The feasibility of developing electrolytic cells which will enable production of ammonia. at a cost of about Rs.380/- per tonne with a cost of power of 2,8 Paise per KWh.

There can be optimistic and pessimistic views in relation to both these assumptions and, fearing that a debate concerning them might delay what is otherwise a most exciting project, we have estimated the implications of a Complex of "Limited" scope utilising immediately available technologies. 200 MW power stations with CANDU type reactors are now being built in India with an 80 per cent indigenous content. Phosphorus furnace technology has been well developed by the Tennessee Valley Authority in USA. In consequence, our "Limited" complex assumes to start with a power station with two CANDU type reactors of 250 MWe each, and a phosphoric acid plant using an electric furnace to supply the phosphatic fertilisers required for the region. Electricity is used for energising the tubewells. The nitrogenous fertiliser plant based on electrolysis has been omitted from the scheme and it is assumed that the required amount of fertilisers will be obtained from elsewhere at the pool price. Aluminium plant has been Omitted as it is not essential for the Agro-Industrial Scheme. The capital requirement for such a scheme is about Rs.1000 crores (Table 10). The operating costs of the project are outlined in Table 11. The annual expenditure amounts to about Rs.431.6 crores. Table 12 shows that the net return on incremental investment of the project will be 81.7 per cent. The higher return on investment compared to the scheme for the full complex is due to the increased share of agricultural activity in the project as a whole.

We should note that the investment figure indicated in the proposal includes about Rs. 114 crores for augmenting the transportation system in the area through building roads, laying new railway tracks and acquisition of rolling stock; Rs.220 crores on rural electrification and tubewells;

Rs.240 crores on agricultural implements; Rs.100 crores for warehouses and Rs.133 crores on credit to farmers and intermediary agencies. Thus, almost half of the investment is on what might be termed the infra-structure of the area. In a real enumeration of the new works to be undertaken, one should take credit for what exists. And in reckoning the additional resources required during the Fourth Plan to implement this project, one should reduce the amount to the extent that State or Central schemes have already been earmarked for part of the projects included in the "limited" complex. In the following sections, the contribution to the infra-structure is discussed in more detail.

VI. LOGISTICS

A scheme of the magnitude described here presents many problems of logistics. For the smooth and uninterrupted operation of the complex reliable sources of supply for raw materials have to be established and provision made for the supply, storage and distribution of the products.

During construction phase, the major problems are associated with the transportation of special industrial equipments, having off-standard size, weight and dimensions by rail or road. The heaviest equipment for a large nuclear power project may weigh as much as 500 tons and the biggest one may be 25 feet long x 20 feet wide x 10 feet high. For this a suitable road, rail or road-cum-rail route will have to be selected end then the whole route length will have to be surveyed for strengthening weak sections, bridges, culverts etc. and for widening road turnings.

During the operational phase, adequate transportation facilities for moving raw-materials regularly into the complex and products out of the complex have to be provided. For the "full" complex, the load on various modes of transportation is shown in Fig.5. The total incoming railway

traffic on account of raw materials and agricultural inputs is expected to be 1.8 million tonnes per year. Of this, rock phosphate, bauxite, potassic fertilisers and Potato seeds together account for approximately 95%. The total outgoing railway traffic from the complex cannot be assessed at this stage as the farms within the complex chosen for intensive cultivation have not been identified. However, it is expected that this traffic will be mainly due to the movement of foodgrains and potato towards Eastern U.P. and to a much less extent on account of fertilisers going beyond 150 Kms from the fertiliser factory of the complex but within the three divisions of the complex. The traffic on account of aluminium is very little being equal to 50,000 tonnes per year, compared to 0.6 million tonnes per year of fertilisers and 7.2* million tonnes per year of food-grains and potato. It is difficult to assess the financial involvement for improving all the railway sections involved, at this stage. Nevertheless on a rough basis we estimate that the direct expenses involved for loading unloading and yard facilities and some of the line-capacity-works in the three divisions of the complex, may be of the order of Rs.25.0 crores. Also, the rolling stock to take care of the transportation requirements of the complex may cost about Rs.85 crores.

The road traffic on account of raw material moving into the complex should be about 0.28×10^6 tonnes per year, which is mainly due to transportation of silica for the phosphorus furnace from the river beds. The total movements of agricultural and industrial products within the three divisions itself work out to about 23.28×10^6 tonnes per year. Sugarcane alone accounts for more than 50 per cent of this traffic. Foodgrains and potato account for most of the remaining road traffic. In other words, most of the above total road traffic is due to the movement of agricultural products. Evidently the village roads will have to bear a lot of addition

* Assuming A C L the surplus of food grains and potato in the three divisions of the complex is due to the complex itself.

load. These roads at present are in a very poor state and most of them are 'katcha'. The estimate of upgrading these roads to accommodate the additional traffic cannot be assessed with precision. A detailed study will have to be undertaken by the appropriate authorities. Roughly we estimate that about 16,000 Kms of road will be involved and the cost will be about Rs. 16 crores.

VII. STORAGE REQUIREMENTS

Storage facilities for agricultural inputs like seeds and pesticides and for materials like fertilisers and some of the agricultural products will have to be provided at various points of distribution. The total storage requirement providing for peak load is estimated to be 4.00×10^{A} tonnes. This may cost about Rs. 100 crores including cold-storage for potato but excluding that for sugarcane and cotton storage in the factories.

VIII. OWNERSHIP. MANAGEMENT AND IMPLEMENTATION FACTORS

However attractive it may appear on the basis of technical and economic feasibility studies, efficient management is no less important than any other factor for the success of the project. Quick decisions, imaginativ scheduling of construction and production schemes, execution of the project in the shortest possible time, maintenance of high plant and load factors, avoidance of wastage of men and material, obtaining good quality raw material on competitive terms, preventive maintenance to avoid frequent shut down or under-production, quality control of the products, good sales organisation and marketing channels are among the many aspects which make all the differ between success and failure of any enterprise and the Agro-Industrial Complex *in* no exception to this. We discuss some factors relevant to this.

The Industrial Block: The economic evaluation of the agro-industrial complex is based on the assumption of a high load factor of 85-90 per cent. This presupposes good co-ordination between the different units for properly programmed production and also planned shut down of the power plant and the different Industrial units for periodic maintenance, A common management organisation for the entire complex may facilitate this to a large extent. Alternatively, effective liaison between the different units would be required. Nevertheless it is desirable to limit the number of management units to three or four within the complex.

The Agricultural Farm: The irrigation proposal for Western U.P. is different from the existing situation not only in quantitative terms but in qualitative terms also. There are two types of tubewells in U.P. viz. the shallow tubewells and the deep tubewells. Invariably all deep tubewells are owned by the State and all shallow wells are privately owned. The reason for this is that deep tubewells involve a high capital investment (about Rs. 100,000) and also they have a large command area i.e. 100-150 hectares. The shallow tubewells cost about Rs.15,000/- and are within reach of at least the prosperous farmers. On an average they are irrigating only about 8-10 hectares at present Water from the deep tubewell is sold by the State Irrigation Department to the farmers within the command area. On the other hand a shallow well is installed with the sole intention of irrigating one's own land. As the land holdings are small the utilisation factor of the shallow tubewells is very low. Not infrequently shallow wells are installed in the command area of the deep well for supplementary irrigation as the State Government generally follows a policy of extensive rather than intensive irrigation. The result is that whereas the shallow tubewells operate for less than 1200 hours in a year the average operation of a deep tubewell is for more than 3000 hours

in a year. There are also many deep tubewells, for instance in the Meerut District, which log upto 6500 hours. This State of affairs accounts for the disporportionately large number (about 90,000) of shallow tubewells compared to only 618 deep tubewells proposed under the fourth five year plan in the three divisions.

Table 13 compares the proposal for tubewell irrigation under the Agro-Industrial Complex with the existing situation and with the scheme proposed under the State's fourth five year plan. Under the proposed Agro-Industrial Scheme the command areas of the deep and shallow tubewells will be about 92 hectares and 25 hectares respectively. The utilisation factors envisaged for the tubewells are also high, i.e. 75% (6,600 hours) for the deep tubewell and 61.5% (5,400 hours) for the shallow tubewell. Large number of tubewells with low utilisation factor increase the idle capital not only as investment in tubewells but also as increased installed capacity of the power plant. Further tubewells too close to each other results in mutual interference in operation. As can be seen from the table the capital investment on irrigati and power plant under the agro-industrial scheme is Rs. 10.96 per 100 cubic meter per annum against Rs.28.74 as at present and Rs.35.37 proposed under the Fourth Five Year Plan.

The reduced capital investment in a way also indicates the improved load factor of the power system. Achieving high utilisation factor for tubewells is a challenge which has to be met. This may call for radical policies with regard to ownership and management of the tubewells.

As the land holdings are generally very small there will be a large number of farmers within the command area of each tubewell, whether deep or shallow. Water will have to be distributed among them on an equitable basil

In the case of proprietary ownership water could be sold by the tubewell owner to the farmers. This is already being practised by some farmers in U.P. But the experience is that full utilisation of the tubewell capacity is still not achieved and not unusually it results in exploitation of the poorer farmer by the tubewell owner. The State officials are of the opinion that cooperative ownership may have to be initially ruled out as their experience with cooperatives in rural areas is not very encouraging. The record of State tubewells is generally good as far as utilisation factor is concerned. Possibly the tubewells, both deep and shallow, in the Agro-Industrial Complex may have at least initially to be State owned. Subsequent transfer of the ownership to cooperatives on a hire purchase basis can perhaps be considered.

CONCLUSION

Our analysis illustrates how energy can contribute to the economic development of the country. In many areas nuclear energy provides the only economic solution. With imaginative planning and implementation it can bring rich dividends by way of increased food production and lead the country to self-sufficiency. The gains by way of increased utilisation factors are great and this can be achieved by the integrated development of the producing and consuming units and choosing the right type of organisation to run the complex. But the penalty for delay inaction or indecision can also be large.

There is much work to be done before a project of this type can commence. This should involve not only the preparation of detailed project reports for each segment of the complex, but also an appreciation of the time frame in which it could be implemented *a* relation to the commitment of financial and other resources, as well as the profits that could be generated

while the project, as a whole, is being completed. There is no reason why the agricultural part of the project cannot commence with the installation of small "seed" power generating units up to 10 MW in capacity, where the capital investment is not tied to one location and the equipment can be transported without much loss after operating it for three to five years. Gas turbines or even conventional diesel sets involving a capital cost of between Rs. 1,200 and 1,500 per KW would be adequate as "seed" generating units. In hastening the process of rural electrification they could perform a very valuable role while we build our larger power stations and the major transmission systems. It is clear that the main difficulty in a project of this magnitude is not likely to arise from lack of financial or technical resources, but from the demands made for managerial skills and organisation structures catering to the needs of development.

The present study has prepared the base for political decision making at the highest level to ensure that the policy of Government is supportive to the concepts which are involved in realising an Agro-Industrial Complex. The sooner we commit ourselves to projects of this type the greater will be the assurance with which we can look to a better future.

ACKNOWLEDGEMENT

The data presented here are largely based on the results arrived at by the Agro-Industrial Study Team of the Bhabha Atomic Research Centre. We thank the members of the team particularly M.G. Nayar and N.S. Sunder Rajan. Oar thanks are also due to the scientists A.K. Saxena, C.G. Malewar and P.L. Kapur for their assistance in the preparation of the paper especially in helping with the laborious computations. We also acknowledge the assistant of the draftsmen, the artist V.R. Chavan and the supporting staff.

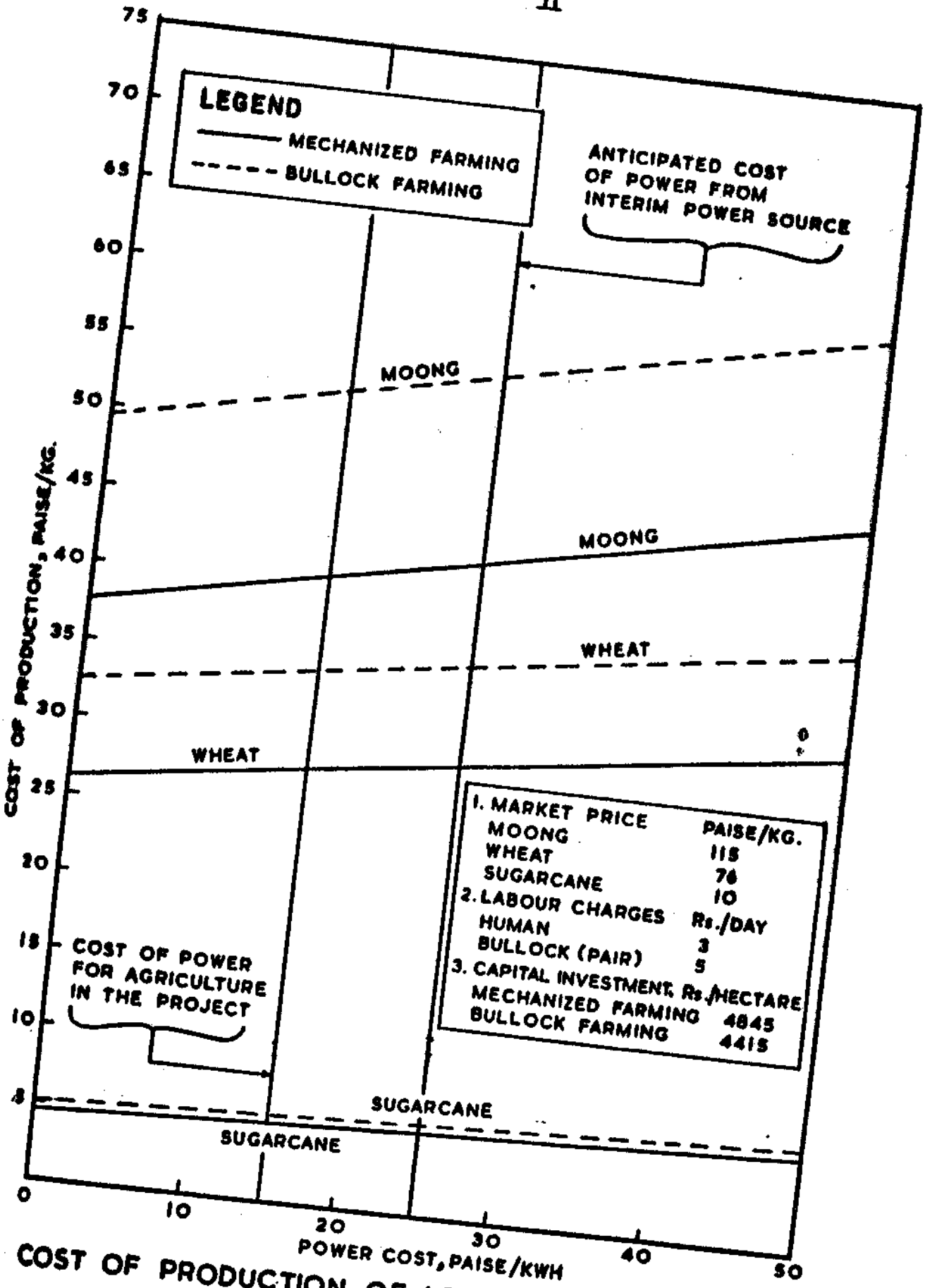
I

INSTALLED POWER CAPACITY IN DEVELOPING COUNTRIES
(as in 1966)

COUNTRY	INSTALLED CAPACITY MWe
1. INDIA	9,745
2. BRAZIL	7,411
3. MEXICO	5,245
4. PORTUGAL	2,144
5. COLOMBIA	1,546
6. TURKEY	1,516
7. U. A. R.	1,469
8. CHILE	1,454
9. PERU	1,148
10. PHILIPPINES	1,085
11. PAKISTAN	1,074
12. THAILAND	559
13. ALGERIA	500

Source: United Nations Statistical Year Book, 1967

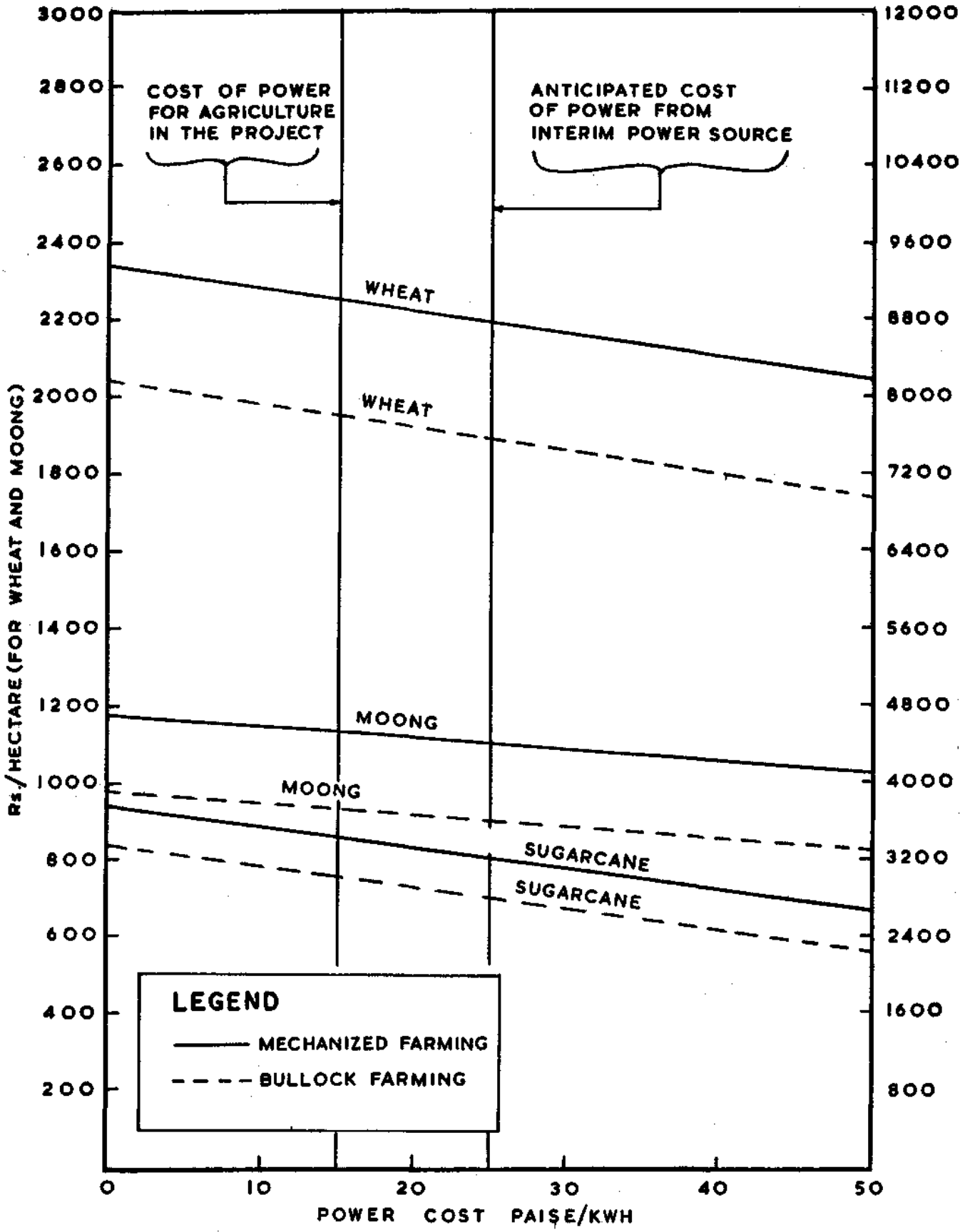
TABLE-1



COST OF PRODUCTION OF AGRICULTURAL PRODUCTS AT VARYING POWER COSTS

DRG. NO. 127

FIG. 1



NET PROFIT AT VARYING POWER COSTS

DRG. NO. 128

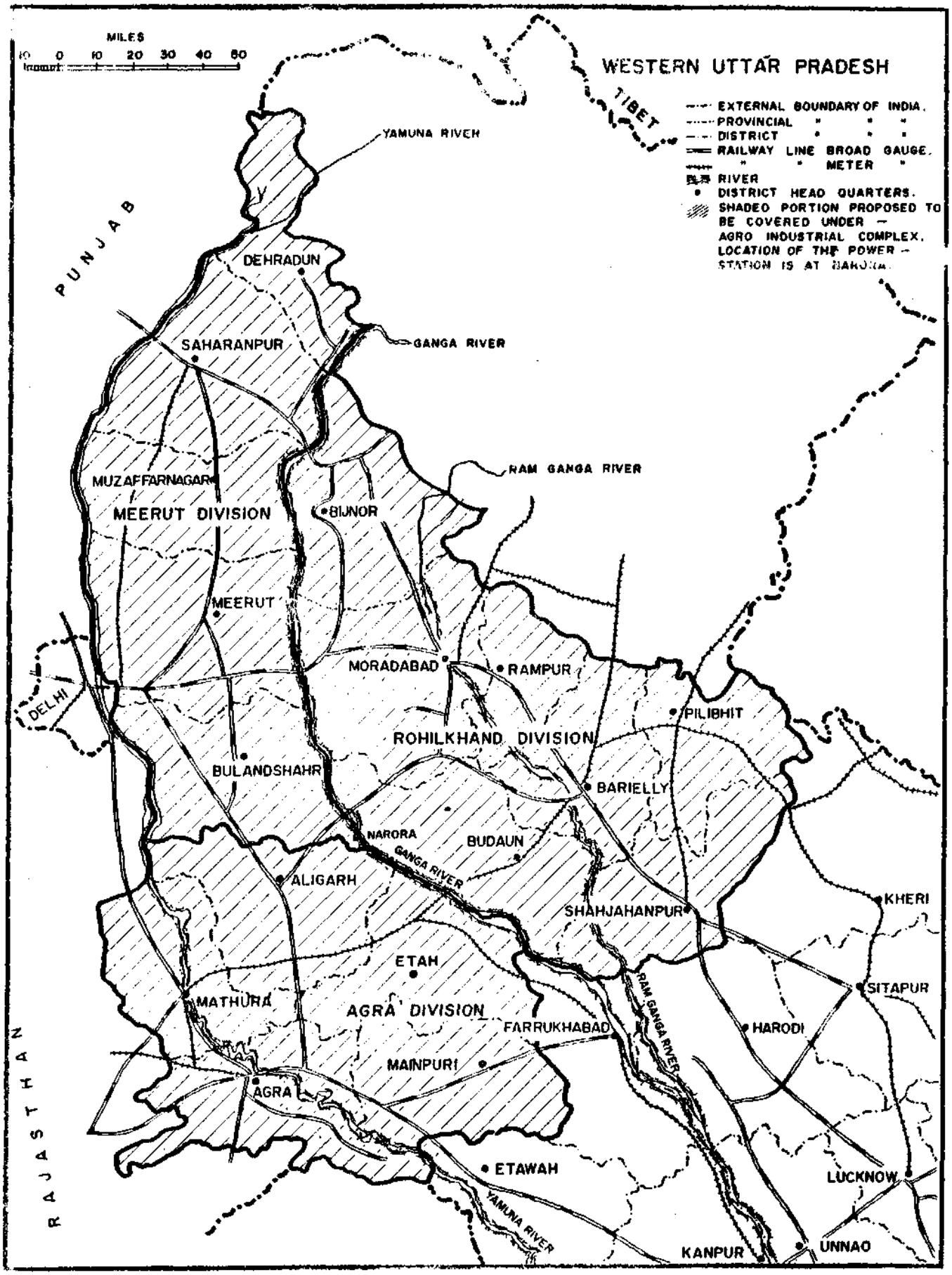

WESTERN UTTAR PRADESH
MILES
10 0 10 20 30 40 50
EXTERNAL BOUNDARY OF INDIA.
PROVINCIAL " " "
DISTRICT " " "
RAILWAY LINE BROAD GAUGE.
" " METER "
RIVER
DISTRICT HEAD QUARTERS.
SHADED PORTION PROPOSED TO BE COVERED UNDER — AGRO INDUSTRIAL COMPLEX.
LOCATION OF THE POWER — STATION IS AT BAHOLIA.
TIBET
PUNJAB
YAMUNA RIVER
DEHRADUN
SAHARANPUR
GANGA RIVER
RAM GANGA RIVER
MUZAFFARNAGAR
MEERUT DIVISION
BIJNOR
MEERUT
MORADABAD
RAMPUR
DELHI
PILIBHIT
ROHILKHAND DIVISION
BULANDSHAHR
BARIELLY
NARORA
BUDAUN
GANGA RIVER
ALIGARH
SHAHJAHANPUR
KHERI
ETAH
SITAPUR
MATHURA
AGRA DIVISION
FARRUKHABAD
RAM GANGA RIVER
HARDOI
MAINPURI
AGRA
RAJASTHAN
ETAWAH
LUCKNOW
YAMUNA RIVER
KANPUR
UNNAO

FIG. 3

AGRO-INDUSTRIAL COMPLEX
WESTERN UTTAR PRADESH

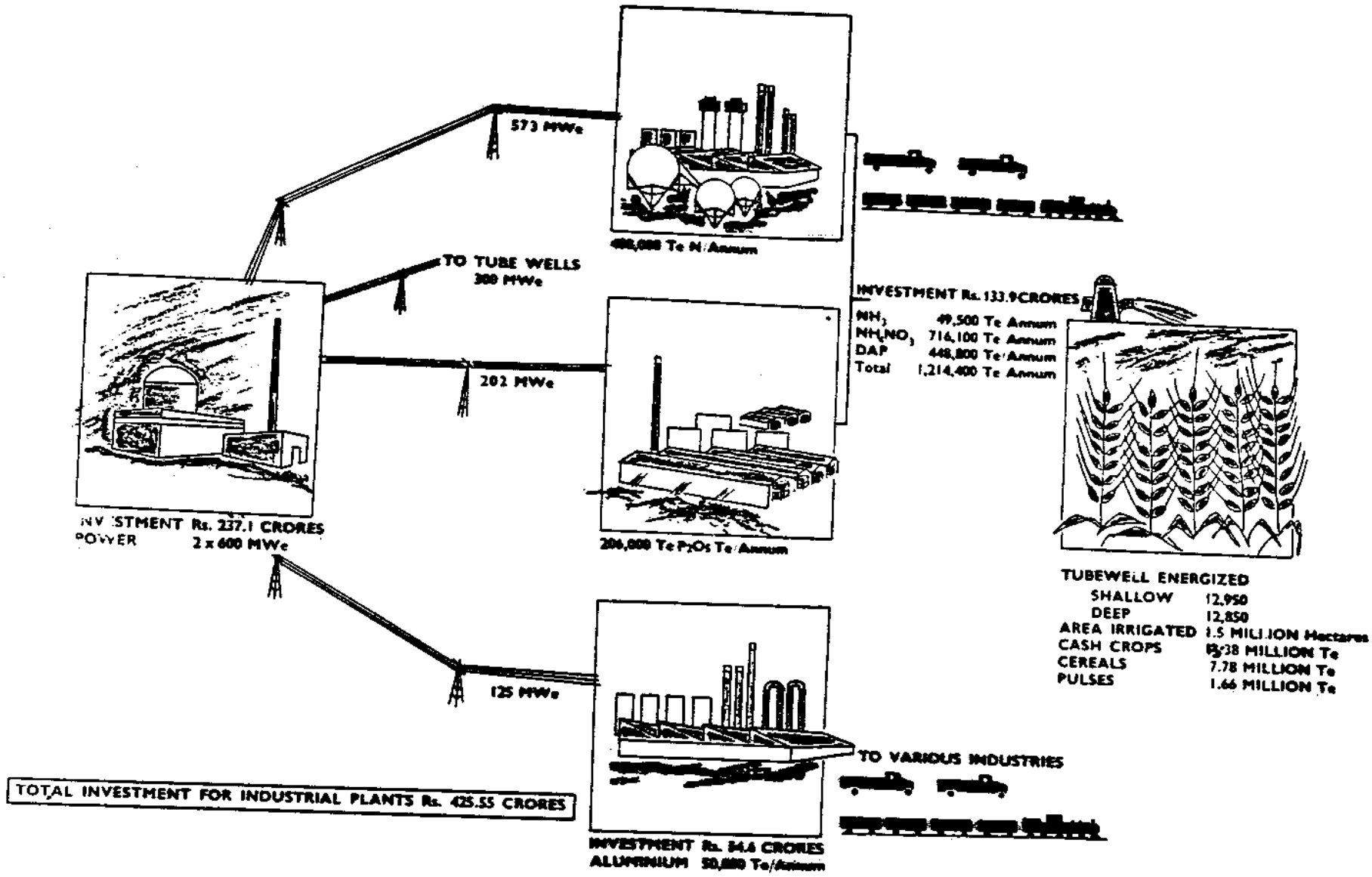


FIG. 4

VI Agro-Industrial

Complex—Western Uttar Pradesh

Agricultural Economics of the Project

Area proposed to be irrigated	:	1.5 million hectares
No. of Tubewells	:	25,800
a) Shallow	:	12,950
b) Deep	:	12,850
Annual Agricultural Production (additional)	:	22.82 million tonnes
Net annual returns from agriculture:		
Mechanized farming	:	721.5 crore rupees
Bullock farming	:	640.6 crore rupees
Annual Fertiliser requirements	:	643,902 Te
Investment on Agriculture :		
Mechanized farming	:	726.79 crore rupees
Bullock farming	:	662.29 crore rupees
Net annual returns :		
Mechanized farming	:	4,810 rupees/hectare
Bullock farming	:	4,271 rupees/hectare

VII

Agro-Industrial Complex—Western Uttar Pradesh

Farm Balance Sheet

Area : 100 hectares

Income	Item		Expenses	
			Mechanized farming	Bullock farming
Rs. 827,520	1.	Seeds	Rs. 34,010	Rs. 34,010
	2.	Fertilizers	Rs. 70,070	Rs. 70,070
	3.	Insecticides	Rs. 12,370	Rs. 12,370
	4.	Operation & Maintenance	Rs. 33,730	Rs. 7,870
	5.	Power	Rs. 15,260	Rs. 15,260
	6.	Labour	Rs. 49,340	Rs. 138,433
	7.	Depreciation	Rs. 31,270	Rs. 27,100
	8.	Transport	Rs. 10,980	Rs. 10,980
	9.	Storage	Rs. 1,300	Rs. 1,300
	10.	Interest	Rs. 31,678	Rs. 26,480
	II.	Rent	Rs. 50,000	Rs. 50,000
	12.	Taxes	Rs. 6,470	Rs. 6,470
		TOTAL	Rs. 346,478	Rs. 400,343
Net profit :				
I. Mechainized farming :			Rs. 827,520-346,478 = 481,042 = 4810/ hectare	
2. Bullock farming :			Rs. 827,520 - 400,343 = 427,177 =Rs. 4271/ hectare	

TABLE-3

VIII Agro-Industrial Complex —Western

Uttar Pradesh

Operating Costs & Profits

Plant		Operating costs crores of Rupees	Revenue from sales crores of Rupees	Profit crores of Rupees	% Return on investment
1.	Power Plant	23.896	32.621	8.725	9.68
2.	Fertilizer Plants*	63.694	85.639	21.945	22.39
3.	Aluminimum Plant	21.799	27.000	5.201	15.23
4.	Total for industrial complex.	109.389	145.260	35.871	14.39
*Anhydrous Ammonia, Ammonium Nitrate & Diammonium Phosphate					T-3

TABLE-4

Agro-Industrial Complex—Western Uttar Pradesh

Investment Costs

Plant		Capacity	Costs	
			Foreign Exchange crores of Rupees	Total crores of Rupees
1.	Power Plant	1,100 MWe	44.792	223.962
2.	Fertiliser Plants*	1.46 x 10^6 Te/annum	34.207	131.561
3.	Aluminium Plant	5 x $I0^4$ Te/annum	20.830	54.560
4.	Total for industrial complex		99.829	410.083

***Anhydrous ammonia—0.54 x 10^5 Te/annum**
Nitric phosphate —1.41 x 10^6 Te/annum **T-4**

TABLE-5

Agro-Industrial Complex—Western Uttar Pradesh

Operating Costs & Profits

	Plant	Operating costs crores of Rupees	Revenue from sales crores of Rupees	Profit crores of Rupees	% Return on Investment
1	Power Plant	22.478	31.322	8.844	9.95
2	Fertiliser Plants*	55.318	87.661	32.343	30.585
3	Aluminium Plant	21.799	27.080	5.201	15.23
4	Total for Industrial complex.	99.595	145.983	46.388	17.27
* Anhydrous ammonia ft Nitric Phosphate					T-5

IX

TABLE - 6

Agro-Industrial Complex—Western Uttar Pradesh
Overall Capital Outlay

(Covering 17 Districts of U. P. Total Geographical area 77,200 sq.km)

		Capital Cost*			
	Item	Bullock Crores of rupees	farming million U.S. Dollars	Mechanized Crores of Rupees	farming million U. S. Dollars
1.	Power plant	237.1	316.1	237.1	316.1
2.	Fertiliser plants	133.9	178.5	133.9	178.5
3.	Aluminium plant	54.6	72.8	54.6	72.8
4.	Rural electrification grid & tubewells	220.3	293.7	220.3	293.7
5.	Transport facility improvements** (Roads and tracks & rolling stock)	113.7	151.6	113.7	151.6
6.	Credits : Rural and for				
	Intermediaries	158.2	210.9	133.3	177.7
7.	Agricultural implements & warehouses	250.0	333.3	339.5	452.7
	Total	1167.8	1556.9	1232.4	1643.1

*** Includes working capital**

**** Includes Rs. 90 crores for improving railway track and for rolling stock and Rs. 7.7 crores for road transport vehicles.** **T-7**

TABLE-7

Agro-Industrial Complex — Western Uttar Pradesh Overall Operating Expenses for the Complex

Item	Expenses			
	Bullock Farming		Mechanized Farming	
	Crore Rupees	Million U.S. Dollars	Crore Rupees	Million U.S. Dollars
1. Power Pant	9.7	12.9	9.7	12.9
2. Fertiliser plants	40.7	54.3	40.7	54.3
3. Aluminium Plant	17.0	22.7	17.0	22.7
3. Agriculture*	460.1	613.5	352.8	470.4
Total	527.5	703.4	420.2	560.3

* Includes transportation costs.

T-8

TABLE-8

Agro-Industrial Complex —Western Uttar Pradesh Return on Investment from the Complex

	Bullock farming		Mechanised farming	
	Crore Rupees	Million U.S. Dollars	Crore Rupees	Million U.S. Dollars
Gross Revenue from sales	1,193.3	1,591.0	1,193.3	1,591.0
Expenses	527.6	703.4	420.2	560.3
Net returns	665.7	887.6	773.1	1,030.7
Total capital investment*	1,070.0	1,426.7	1,135.0	1,513.3
Return on investment	62.2%		68.1%	

*Excluding road transport vehicles, improvements in tracks and rolling stock

Agro-Industrial Complex—Western Uttar Pradesh Overall Capital Outlay

(Alternative Scheme) (Covering 17 Districts of U. P. Total Geographical area 77,200 sq.km)

Item	Capital Cost*	
	Crores of rupees	million U.S. Dollars
1. Power plant	150.0	200.0
2. Fertiliser plants +	40.0	53.3
3. Rural electrification grid and tubewells	220.3	293.7
4. Transport facility improvements** (Road, track and rolling stock)	113.7	151.6
5. Credits : Rural and intermediaries	133.3	177.7
6. Agricultural implements and warehouses	339.5	452.7
Total	996.8	1329.0

*** Includes working capital**

**** Includes Rs. 90 crores for improving railway track and rolling stock facilities**

+Triple Super Phosphate

T-I I

TABLE-10

Agro-Industrial Complex—Western Uttar Pradesh Overall Operating Expenses for the Complex

(Alternative Scheme)

Item	Mechanized Farming Expenses	
	Crore Rupees	Million U.S. Dollars
1. Power Plant	5.0	6.6
2. Fertiliser Plants*	18.4	24.5
3. Agriculture**	408,2	544.3
Total	431.6	575.4

* Triple Super Phosphate

** Includes transportation

T-12

TABLE-11

Agro-Industrial Complex—Western Uttar Pradesh Return on Investment from the Complex

(Alternative Scheme)

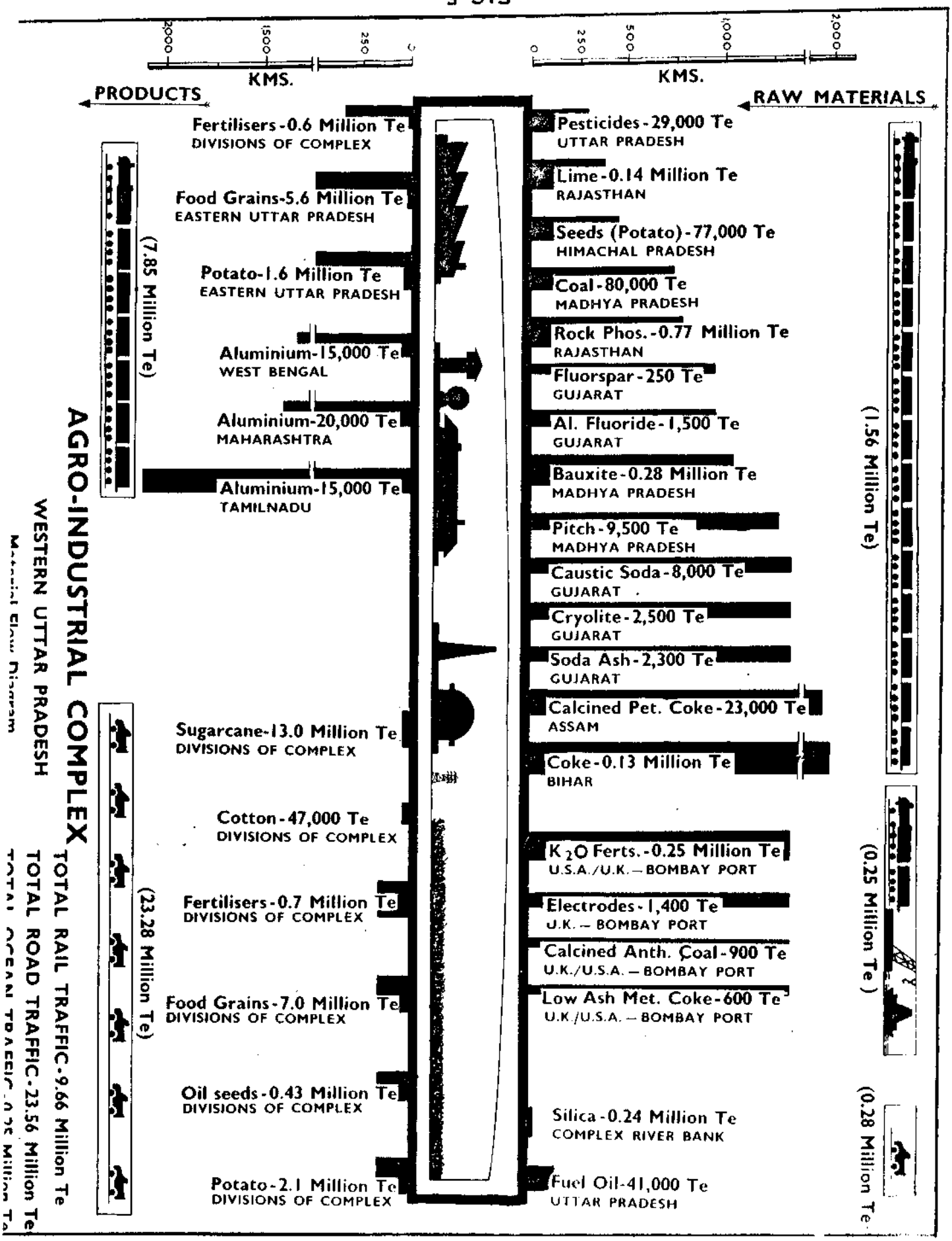
	Mechanized farming	
	Crore Rupees	Million U.S. Dollars
Gross Revenue from sales	1,166.3	1,555.0
Expenses	431.6	575.4
Net returns	734.7	979.6
Total capital investment*	899.1	1,198.8
Return on investment	81.7%	

* Excluding road transport vehicles, improvements in tracks and rolling stock.

T-13

TABLE-12

FIG. 5


AGRO-INDUSTRIAL COMPLEX
WESTERN UTTAR PRADESH
Material Flow Diagram
TOTAL RAIL TRAFFIC-9.66 Million Te
TOTAL ROAD TRAFFIC-23.56 Million Te
TOTAL OCEAN TRAFFIC-0.25 Million Te
PRODUCTS
KMS.
2000
1500
250
0
(7.85 Million Te)
Fertilisers-0.6 Million Te
DIVISIONS OF COMPLEX
Food Grains-5.6 Million Te
EASTERN UTTAR PRADESH
Potato-1.6 Million Te
EASTERN UTTAR PRADESH
Aluminium-15,000 Te
WEST BENGAL
Aluminium-20,000 Te
MAHARASHTRA
Aluminium-15,000 Te
TAMILNADU
(23.28 Million Te)
Sugarcane-13.0 Million Te
DIVISIONS OF COMPLEX
Cotton-47,000 Te
DIVISIONS OF COMPLEX
Fertilisers-0.7 Million Te
DIVISIONS OF COMPLEX
Food Grains-7.0 Million Te
DIVISIONS OF COMPLEX
Oil seeds-0.43 Million Te
DIVISIONS OF COMPLEX
Potato-2.1 Million Te
DIVISIONS OF COMPLEX
RAW MATERIALS
KMS.
0
250
500
1000
2000
(1.56 Million Te)
Pesticides-29,000 Te
UTTAR PRADESH
Lime-0.14 Million Te
RAJASTHAN
Seeds (Potato)-77,000 Te
HIMACHAL PRADESH
Coal-80,000 Te
MADHYA PRADESH
Rock Phos.-0.77 Million Te
RAJASTHAN
Fluorspar-250 Te
GUJARAT
Al. Fluoride-1,500 Te
GUJARAT
Bauxite-0.28 Million Te
MADHYA PRADESH
Pitch-9,500 Te
MADHYA PRADESH
Caustic Soda-8,000 Te
GUJARAT
Cryolite-2,500 Te
GUJARAT
Soda Ash-2,300 Te
GUJARAT
Calcined Pet. Coke-23,000 Te
ASSAM
Coke-0.13 Million Te
BIHAR
(0.25 Million Te)
K2O Ferts.-0.25 Million Te
U.S.A./U.K.—BOMBAY PORT
Electrodes-1,400 Te
U.K.—BOMBAY PORT
Calcined Anth. Coal-900 Te
U.K./U.S.A.—BOMBAY PORT
Low Ash Met. Coke-600 Te
U.K./U.S.A.—BOMBAY PORT
(0.28 Million Te)
Silica-0.24 Million Te
COMPLEX RIVER BANK
Fuel Oil-41,000 Te
UTTAR PRADESH

TUBEWELL IRRIGATION
in Western Uttar Pradesh

	At present		Proposed under fourth five year plan		Proposed under the Agro-Industrial Scheme	
	Shallow well	Deep well	Shallow well	Deep well	Shallow well	Deep well
Number of wells	54,025	4,915	87,000	618	12,950	12,850
Operation : hrs/yr.	1,200	3,000	1,200	6,600	5,400	6,600
Water pumped : cmre/yr per pump	61,097	458,231	61,097	1,008,109	274,939	1,008,109
			Capital investments			
Tubewells*	19.64	17.43	19.64	7.94	4.36	7.94
Power plant*	16.13	8.66	16.23	3.93	3.91	3.93
Tubewell + Power Plant*	35.87	26,09	35.87	11.87	8.27	11.87
Average on tubewell + Power plant*	28.74		35.37		10.96	

'Rupees per 100 cubic metres per annum

T-15

TABLE-13

Appendix-1.

WESTERN U.P. REGION ANNUAL IRRIGATION REQUIREMENT FOR AGRO-INDUSTRIAL

S.No.	Crop rotation	Area (heactre)	Irrigation requirement (supplemental) for Crop rotation (inches)	Total water required Million acre ft./year
1	Maize-Toria-Wheat	78950	39.1	0.6192
2.	Maize-Potato-Wheat	76950	56.0	0.8869
3.	Bajra-Wheat-Moong	306750	32.0	2.0202
4.	Maize-Wheat-Moong	76950	37.5	0.5939
5.	Rice-Wheat-Moong	123450	45.0	1.1434
8.	Groundnnt-Wheat-Maize	49350	40.5	0.4114
7.	Rice-Gram-Maize	123450	40.5	1.0290
8.	Rice-Gram-Moong	123450	39.0	0.9909
9.	Jowar-Wheat-Moong	822000	38.6	0.6531
10.	Cotton-Toria-Wheat	15900	41.5	0.1358
11.	Cotton-Toria-Gram	15900	37.1	0.1214
12.	Groundnut-Wheat-Moong	49200	39.0	0.3949
13.	Sugarcane	307920	40.0	2.5351
14.	Tur-Wheat-Moong	71550	33.0	0.4859
	Total :	15,00,000		12.0211
			Distribution losses	1.2021
			=	13.2232 Million acre

Average irrigation water requirement $= \frac{13.2232 \times 12 \times 10^6}{1.5 \times 2.47 \times 10^6} = 42.83''$ **App. 43".**

*** For irrigation requirements of Kharif crops, effective rainfall has been deducted from the total water requirements of the crops.**

INSAT —A NATIONAL SATELLITE FOR TELEVISION AND TELECOMMUNICATION

by
Vikram Sarabhai, E. V. Chitnis, B. S. Rao, P. P. Kale and K. S. Karnik

(Invited paper presented by Dr. Vikram Sarabhai at Session IX of the National Conference on Electronics, Bombay—March 24-28, 1970).

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When we consider television for India and the hardware system that would be required for it, we suggest that the following premises be accepted :

1. We recognise that television can be a most important tool for development. In this context, its impact is at least as relevant, if not more so, to the isolated rural communities where the bulk of our population resides as it is to the urban population already subject to other major influences of modernisation.

2. National T. V. programmes accessible through community receivers to all our clusters of population, urban as well as rural, permitting shared audio-visual experiences, can be a most important factor for national integration. Therefore, it is necessary to have a broad-band communications system suitable for a national hook-up of television particularly reaching remote areas where the population density is small, as in our border regions.

3. By providing entertainment and instruction of a high standard, T.V. can produce a qualitative improvement in the richness of rural life and thereby reduce the overwhelming attraction of migration to cities and metropolitan areas.

If you go along with these premises, which we suggest should be the subject of political decision making, it is easy to demonstrate that by far the most cost effective solution is a hybrid system which utilises a synchronous satellite providing the broad-band communication link: for rediftusion from ground stations in areas where the density of sets is large, and direct broadcast

receivers where the density of sets is low. The precise cross-over point from one diffusion system to the other in individual regions of the country is dependent on factors which have to be decided technically and economically after practical experience during the DAE-NASA experiment.

If we are to have a large number of rediffusion stations, then for a national hook-up it would still be more economical to use a satellite for inter-connecting all the rediffusion stations. For example, when we connect all rediffusion stations, which may be located as far apart as Delhi and Trivandrum, via ground micro-wave links for television, we would be tying up all the units along the line between the two points and also similarly all such lines which will be utilised for transmission of the same programme to various rediffusion stations. The impact of this can be judged by noting that the 25 Megacycle bandwidth which will be required for good quality television will take up about 400 channels available for good quality voice communications for telephones which would otherwise be available for the intermediate stations. In the case of the national hook-up, when all these rediffusion stations are inter-connected to a transmitting station using a satellite, it represents only the capacity of one T.V. channel utilisation.

2. DAE — NASA **Experiment**

The details of the DAE NASA ITV experiment which is to be conducted in 1972-73 have already been announced earlier, and are contained in the paper "Television for Development" which was presented at the XI World Congress of the Society for International Development in November 1969.

Let me recapitulate the main points : The experiment will be conducted with the ATS-F spacecraft of NASA which forms part of the US programme of Applications Technology Satellites. It would be the first time that a 30 ft. dish antenna would be deployed with a satellite transmitter of large power. The effective isotropically radiated power would be as high as + 51 dbw which is equivalent to 125 kw. Details of the satellite which are not furnished in the paper "Television for Development" are given in Annexure 1. The primary television signals will be programmed in India entirely under Indian responsibility and would be transmitted from the Experimental Satellite Communications Earth Station at Ahmedabad and from the new earth terminal for the Overseas Communications Service to be installed near Delhi. Figure 1 shows the antenna of the Ahmedabad earth terminal. For rediffusion of these signals, a 30 ft. dish type antenna would be adequate. For the direct broadcast receivers a chicken mesh type antenna of 10 ft. diameter would be required for each community

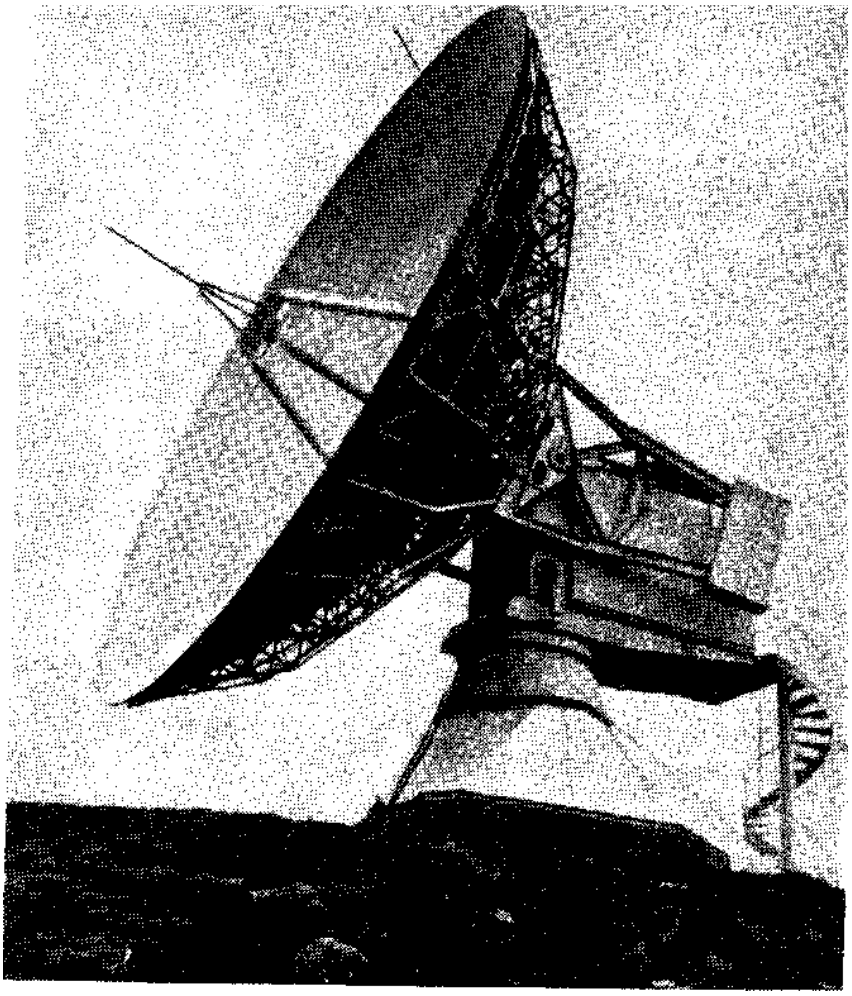
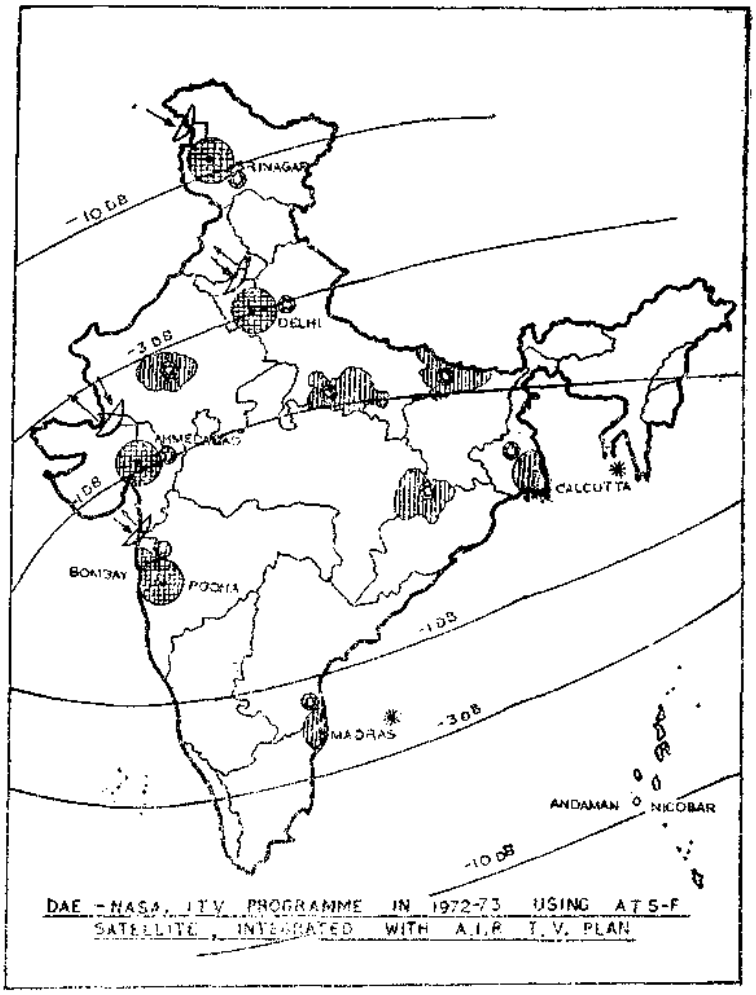


Fig. 1

receiver. The receiver itself will be of a conventional type but will have a front-end converter to accept a down Jink 850 Megacycle FM signal. The proposed configuration of T.V. service during the DAE - NASA experiment integrated with the AIR plan is given in Figure 2. The major tasks in electronics that would be undertaken in India and which are the responsibility of the Indian Space Research Organisation (ISRO) are given in Annexure *2*.



Clusters using Rediffusion TV at **V.H.F.**

Clusters using Direct Broadcast TV at 50 MHz with about 500 Community Receivers each

Transmit — Receive Satellite Earth Terminal

Receive only Satellite Earth Terminal

Programming Centers

To he converted to Rediffusion TV

3. A Synchronous Satellite for Telecommunications.

Many questions have been raised about the plans of ISRO-DAE for a follow-up after the completion of the DAE — NASA ITV experiment. We would like here to share our current thinking on this subject. Let us note some salient aspects of the peaceful uses of outer space related to synchronous satellites. Table 1 shows that going from a satellite launcher of the Thor Delta

	3 TV+3600 tele. simult.	1 TV	2 TV	1 TV + 1200 tele. not simul.	1 TV + 1200 tele. simul.
Satellite Cost ($M)	8.4	6	6.5	6.3	6.6
Satellite Development Cost ($M)	20.1	15.5	16.5	16.7	17.3
Launch Cost ($M)	10	5	5	5	5
Satellite Weight (lbs.)	1087	525	635	590	610
Prime Power (watts)	2805	615	1260	615	1050

class to an Atlas Agena class the cost escalates from about $ 5 million to $ 10 million per launch. The weight of the satellite that can be put into a synchronous orbit can also be doubled. But, since a substantial part of the weight of a satellite is taken up by its structure and on-board house-keeping, the effective payload weight and the capability of the satellite for communication purposes increase enormously thereby making it much more cost-effective to use the bigger launch vehicle if there are uses to which we can put the larger capacity. There is available today a one million dollar insurance premium for insuring against an abortive launch, and this was done by ESRO recently. When we take into consideration the present experience, the operating useful life of a satellite is about 7 years, but for our consideration we can accept a minimum life time of five years for large communication satellites. The annual allocation of costs for a communication satellite of small configuration would be about 3.5 million dollars and for a large satellite about 5.5 million dollars.

The USSR has a satellite system in operation (called ORBITA) for television distribution, making it possible to have television programmes distributed on a national level. For the educational television network in USA (National Educational Television — NET), NASA has agreed to carry out an experiment for 16 weeks for transmitting programmes from the east coast to the west coast in USA using the ATS — 3 satellite. For defence, United States has many different types of communication satellites at synchronous altitude as well as at lower altitudes for random orbits. The largest communication satellites

for Defence as of today are the TACSATs. Using the high gain antenna and high power transmitters on this satellite, it is possible for a person with a "manpack" to establish communications with another similar unit via the satellite. The United Kingdom has already got a satellite in orbit with the help of the United States and the satellite is called SKYNET. This satellite will be utilised for operational defence communications. Recently NASA has launched a satellite for defence communications for NATO and this satellite is called NATO-1. For internal point-to-point telecommunications and distribution of the television programmes, Canada has already carried out a study and has advanced plans for a satellite system, particularly due to the inaccessibility of the northern regions of Canada and its population clusters located in remote areas.

The Australian Post Office has proposed communication experiments using the ATS-1 satellite already in orbit and located over the Pacific. Figure 3 shows

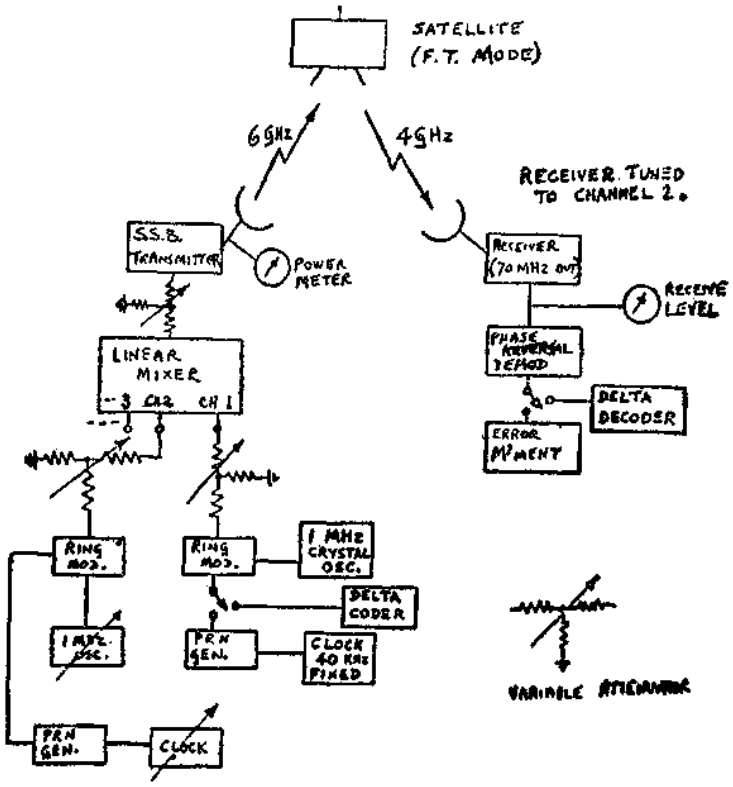


Fig. 3 : Block Diagram of Simulated Port to Outstation Link

Fig. 4

the uplink and down-link station configurations and Figure 4 shows how a possible trunk network could be established using such a satellite. This satellite has an electronically despun antenna. Such an electronically despun antenna gives lower gain than the mechanically despun antenna deployed on the ATS-3 satellite. The experiment envisages use of a possible connection via the satellite for one voice channel communication using a small earth receive-transmit antenna of 12 ft. diameter and 10 to 100 watts of radiated power. The expected cost for such 12 ft. diameter antennae is expected to be about $ 8,000 in USA. It is estimated that we can manufacture 12 ft. diameter antenna usable in the C-Band for about Rs. 15,000 to 20,000. The equipment needed for such communication needs would cost Rs. 1.5 lakhs or so. Using this uplink system, with the spread spectrum technique, it is considered feasible to establish one channel communication from one group to another for trunk telephones. Present calculations show that a total of about 132 channels can be established for trunk communications. The experiment would provide experience in spread spectrum techniques, Psuedo

random noise techniques, Delta Modulation, Pulse Code Modulation operation with a synchronous satellite, and possible integration of a satellite system into existing telecommunication networks.

For our national needs in the time frame of 1974-75, we have taken note of existing experience of communication satellites and consider that the optimum configuration needs the combining of television direct broadcasting and point-to-point telecommunications payloads.

4. INSAT — 1.

The Indian Space Research Organisation of the Department of Atomic-Energy has conducted joint systems configuration studies with General Electric Company and Hughes Aircraft Corporation, two companies in the United States with a great deal of experience in communication satellites. All the studies carried out so far indicate that, considering the very large number of direct receiving systems involved, the cheapest system would be the one which will be operating in the region of about 800 Mc/s to 1000 Mc/s for the direct broadcasting of T.V. However, for telecommunications, it will be best to operate in the common-carrier band as the number of equipment packages involved will be very small and the cost differential, depending upon the frequency, would not be very large. Using the data generated in the joint studies and other developments, ISRO has narrowed the field of options for a national communications satellite. The following are the salient features of the spacecraft system INSAT-1, which could become operational for our national needs in 1975.

1. The satellite will be a three axis stabilised space-craft and will be located at synchronous altitude at about 79° east longitude. This will minimise east-west drift of the satellite.

2. The satellite will have a 23 ft. diameter parabolic antenna to operate in the 800 to 900 Mc/s band, which would result in a beam width of 3.5° and would provide optimum coverage of India.

3. The 23 ft. diameter parabolic reflecting antenna and the power amplifiers in the satellite will provide a useful minimum effective isotropic radiated power of about 53 dbw. The antenna beam could be pointed towards any point on the surface of earth with error less than ± 0.1° peak.

4. The satellite will have a capability to operate 3 high power television channels, each with several audio channels for different languages — and 3600

telephone channels. The transponder configuration selected for telecommunications are selected to have 12 independent transponders, so that the transponder utilisation can be maximised depending upon the demand (Intelsat IV satellite has a similar configuration).

5. The satellite receiver system for television as well as telecommunications will utilise a high gain dish of 3 ft. diameter to provide higher sensitivity in the satellite and thereby reduce the effective isotropically radiated power required for the ground stations. Further, the satellite will also be provided with horn antenna systems to provide a lower gain so that in case a jamming signal is detected, we could switch back to a lower antenna gain on the satellite and secure an effective margin of the order of 15 to 16 db.

5. Potential Applications of INSAT— 1.

We could now consider the use to which INSAT — 1 would be put as well as the users who could be interested in using the INSAT profitably. The contemplated use is for either two-way communications, broadcasting or communications requiring data and information dissemination and are summarised in the chart below :

POSSIBLE USERS OF INSAT

1. ALL INDIA RADIO

   PROGRAM USERS: HEALTH, FAMILY PLANNING, EDUCATION, AGRICULTURE, ETC.

2. POSTS AND TELEGRAPHS/OVERSEAS COMMUNICATION SERVICES

3. DEFENCE: AIR FORCE, ARMY, NAVY

4. MINISTRY OF HOME AFFAIRS:—

   (A) BORDER SECURITY FORCES

   (B) POLICE WIRELESS

   (C) CENTRAL RESERVE POLICE

   (D) INTERNAL SECURITY

5. RAILWAYS

6. CIVIL AVIATION/METEOROLOGY

7. MARINE NAVIGATION/COMMUNICATION
8. INDIAN SPACE RESARCH ORGANISATION/ANDAMAN ISLANDS
9. PRESS TRUST OF INDIA, UNITED NEWS OF INDIA, ETC.
10. LARGE COMPUTER FACILITIES AND DATA HANDLING SYSTEMS ETC.

5.1. AH India Radio

All India Radio can utilise the services provided by INSAT both for direct broadcasting or for rediffusion of the TV broadcast programmes. Using the satellite, the entire country could be illuminated for direct broadcast as well as for the rediffusion systems. All India Radio can also use a transponder on the satellite which will enable them to interconnect all radio stations for a national hook-up so that the quality of national radio programmes/radio news services could be vastly improved by providing better links for transmission. Preliminary analyses show that for a high grade transmission, the systems requirements could be quite modest. The satellite radiated power required would be of the order of only 2 watts which, coupled with the high gain of the antenna, could produce flux density on the surface of India sufficient for being utilised by a system which would consist of a 15 ft. diameter antenna and a 600° Kelvin receiving system. Thus programmes could be beamed towards the satellite and can be received all over India. The relaying systems will need only a small ground terminal. It is estimated that 10 channels of 15 Kc/s bandwidth or 30 channels of 5 kc/s bandwidth should be sufficient for such a service.

5.2. Posts and Telegraphs.

P & T can utilise the services provided by INSAT for mainland domestic communications as well as for communications to our isolated islands. The most important usage commercially would be for carrying point to point communications traffic between the four major centres viz. Bombay, Calcutta, Delhi and Madras. The same transponders used for this could be assigned, on a time-shared basis, for interconnecting remote stations on multiple access systems.

Following the requirements of 12000 circuits (between the 4 major cities of India — Bombay, Calcutta, Delhi and Madras), given by P&T in one of the NASCOM Study Group meetings, a total payload of 3600 channels for tele-communication was included in the satellite con-figuration. The ground terminal at each of the four cities will have a 35 ft. diameter parabolic dish antenna.

Considering the present experiments which are being carried out by the Australian Post Office, as mentioned earlier, one can visualise that during the slack time period in which the circuits on the satellite are not fully utilised by these four major cities, the satellite transponders could be assigned for multiple access systems for communicating with remote areas.

Through the medium of All India Radio, other Ministries and other users who want information to be conveyed but who do not need the medium exclusively can make use of the T. V. Such users would be the Ministry of Health and Family Planning, Ministry of Education, Ministry of Food and Agriculture, Ministry of Civil Aviation and Meteorology, etc.

5.3. Defence.

The defence organisation and the Services could utilise the services provided by INSAT for establishing communications in the remote regions in the hilly areas of Assam, NEFA, Ladakh, Kashmir, etc. Particular consideration could be given for the services which can be provided using a high-power transponder on the satellite and small transportable terminals on the ground. Naval ships equipped with small dishes could establish communication from ship to shore and from ship to ship using the satellite for inter-connection. The Air Force can utilise the communications which would be provided by the links via the satellites to inter-connect all the operational airports. Thus, in an emergency situation, if an airport is built in a forward area, in a very short time (due to the rapid connetivity of the satellite communications) communications can be provided at this airport, where it would otherwise take a long time for terrestrial means of communications.

5.4. Ministry of Home Affairs.

The Ministry of Home Affairs could secure communications facilities for the Border Security Force, the Central Reserve Police and other internal security units.

5.5. Railways.

The Railways are in the process of installing their own microwave communication systems for communications pertaining to their needs. These communications facilities can be augmented by using satellite channels, particularly at Divisional Headquarters levels, so that the in-between routes of micro-wave communication systems could be freed for carrying the traffic for intermediate stations.

5.6. Ministry of Civil Aviation and Meteorological Department.

The Ministry of Civil Aviation could utilise the communications provided by the satellite, particularly for inter-connecting all the civil airports. Thus, operational co-ordination between all the airports can be maintained in a better manner and also meteorological data could be transmitted from one airport to all the concerned airports very quickly and very effectively. Moreover, the same facility could be used by Indian Airlines for their operations coordination.

The satellite system can be used for dissemination of the meteorological data, particularly by putting it on the AIR television bioadcast for farmers and the AIR radio broadcasts for the farmers etc. With the availability of the cloud pictures and the satellite data using the TIROS, NIMBUS and ESSA satellite systems, precise methods of weather predictions can be evolved.

If the predictions about hurricanes, gales etc. are transmitted to the coastal villages via television, our fisheries would benefit extensively as most of our country-crafts are not equipped with any kind of radio facility which could be used for receiving warnings etc. The information transfer to the fishermen is otherwise very poor. However, using television in each village of India, information about weather conditions could be relayed to every corner of the country and such information could then be profitably put to use.

5.7. **Marine Navigation and Communications.**

It might be worthwhile at this stage to consider the usage of a satellite system for marine navigation and communications. Our ships carrying cargo and passengers as well as ships of the Navy and ships of various fisheries departments which are involved in deep sea fishing could maintain better communications with shore facilities via the satellite.

5.8. Press.

Major newspapers are published simultaneously in many cities. Such newspapers could use high speed facsimile systems using 50 kilobit/sec. data rate. Such a data rate makes it possible for transmission of one newspaper page within about 3 to 4 seconds.

5.9. Data Handling.

The requirements for data transmission and inter-connection of large computer facilities have not yet come up in our country. However, one can

visualise that such needs will arise for inter-connecting large computers on a time-sharing system. Such communications could be handled very effectively by the satellite.

6. Satellite and Ground Telecommunications.

The satellite systems as considered earlier could be integrated into the existing telecommunications net-work very easily as the satellite system here is planned in such a manner that the system will augment the terrestrial communications capability. A simple calculation can be made for estimating the revenue that could be earned by the use of the telecommunications capacity on the spacecraft, INSAT-1.

The following is a summary of the total amount of revenue which could be earned by the utilisation of the telecommunication capacity on INSAT-1. Details of this have been given in Annexure 3.

The charge could be levied at a rate of 5 paise per second. This charge would be lower than the charge which is presently worked out for the Subscriber Trunk Dialling (STD) calls between Bombay and Calcutta or Bombay and Delhi. Considering that the total channel capacity available on the satellite will not be fully utilised, it is estimated that the channel capacity utilisation will be only about one-sixth or one-fourth, due to the patterns in utilisation of the telecommunication links. Out of this revenue, one-third would be earmarked for the operations of the terminal equipment. Then the revenue which has been worked out for the satellite turns out to be Rs. 43 crores per year for one-sixth capacity utilisation, and Rs. 65 crores per year for one-fourth capacity utilisation. This could be averaged to Rs. 54 crores per year, which represents a total earning of the order of Rs 270 crores over the five year life-time of the satellite.

Similarly, calculations could be carried out for the transponder usage by AIR. These are as follows :—

Required time ..... 20 hours. = 7.2×10^4 secs. in a day.

30 channels.

10 channels utilisation .....7.2×10^5 seconds which could be charged

2 Paise per second.. Rs. 14.4×10^3 per day.

365 days .....Rs. 5.256 million per year.

These calculations are carried out at a rate which is smaller than the usual rate of STD calls.

7. National Strategy for a Television and Telecommunications Satellite.

In a ten year time frame, one must acquire the capability not only of building telecommunication satellites such as INSAT-1 but also of launching them into synchronous orbit from our new range at Sriharikota Island. This, however, requires that we have an adequate satellite launch vehicle with accurate guidance and control systems. It should be comparable, at least, to the performance of the rockets like Thor Delta and Atlas. However, this requires a great deal of effort in highly sophisticated space technology and, to begin with, we have set as a goal the development of a satellite launcher of the Scout type to be completed in about four years from now. This will only be adequate for putting into low level orbits scientific or applications satellites of an all-up weight of 20 to 40 kg. But once the basic systems have been developed for this, and experience acquired in operating them, it is estimated that a five year period from 1975 to 1980 should be adequate for the second stage of development of the laiger booster.

Meanwhile, there is much to be learnt in the designing and building of communications satellites and we propose that by 1974-75, we should build one in collaboration with a country advanced in space technology and to be launched also by an outside agency. Typically, at least 3 satellites are built before one is launched and it is our intention that during the next three years, some 30 or 40 Indian engineers participate in constructing the first proto-type abroad, but the second and the third units would be built in the new facilities being established at the Space Science and Technology Centre at Veli near Trivandrum. There is likely to be a need to import a considerable number of specialised components for the first two satellites that would be built here by 1975, but a very major step forward would have been taken in India in acquiring competence to proceed for the second generation communications satellite largely on our own designs. These would be needed only by 1980 since the effective time of operation of our INSAT-1 should cany us from 1975 to 1980.

The programme which we have outlined here represents a most challenging task for Indian scientists and engineers. Electronics will play a very important part in various phases of the programme — in the electronic instrumentation involved in the control and guidance of the rocket, the solar power sources to be put on the satellite, the transponders for television and telecommunication, the digital control systems, the telemetry and tele-command systems and the ground radar and tracking net-work. On the ground segment, there would be need for earth terminals, solid state television receivers at the rate of at least 100,000 to 200,000 a year, a large number of micro-wave and UHF antennas,

studio equipment for television, video tape recorders and a whole lot of test and calibration instruments. We are glad to have this opportunity to unveil the first outlines of this project at this national gathering on electronics. This is because we expect that in the true spirit of the Bhabha Committee Report, the task involves every segment of the nation which can make a contribution to it.

Following is a brief description of ATS-F Spacecraft :

The salient features particularly of relevance to DAE/NASA experiment are enumerated.

1. The satellite will be a 3 axis stabilised spacecraft and will be located within operating view of India for the conduct of the experiment.

2. The satellite will have a 30 foot diameter parabolic antenna which will be used to beam the transmitted energy towards India.

3. The UHF feed will be on center and the ATS vehicle will point the 30 foot diameter antenna anywhere within a solid angle of ± 8° to the local vertical.

4. The 30 foot diameter parabolic reflecting antenna, considering the loss and the power output of the amplifiers, will provide a useful minimum Effective Isotropically Radiated Power of + 51 dbw.

5. The antenna beam will be pointed towards any point on the surface of earth with error less than ± 0.1° peak.

6. The satellite will receive TV transmission, beamed towards the satellite, by using an earth coverage fixed horn antenna operating in the C-band at about 6GHz.

7. An overall satellite receiver system figure of merit will be about — 17db/°K.

8. The receiving antenna on the satellite will be linearly polarized while the transmitting polarization will be right hand circular. The estimated beamwidth for the UHF beam will be about 2.6° to 2.9°.

9. The microwave receiving subsystem on the satellite will have a nominal noise bandwidth of 40 MHz.

10. The central frequency of UHF transmitting subsystem on the satellite will be 850 MHz nominal.

ANNEXURE 2

Research and Development Problems Visualised in the DAE-NASA **Satellite TV Experiment.**

The memorandum of understanding signed on September 18, 1969 between the Department of Atomic Energy (DAE) and the National Aeronautics and Space Administration (NASA) clearly identifies the responsibilities of these two agencies for the conduct of the satellite TV experiment. According to this, the DAE has the entire responsibility to provide the hardware requirements of the ground segment, besides programming. A systematic analysis conducted on the hardware requirements has been helpful in identifying the following equipment and systems as required for the experiment.

(a) Earth stations for reception only from the satellite and also for reception and transmission to the satellite.

(b) VHF transmitting stations and associated studio equipment.

(c) 10 feet chicken mesh antennas.

(d) Front-end converters for direct reception.

(e) Solid state community television receivers.

(f) Primary power sources.

A study of the above requirements along with the available technology reveals that immediate development work has to be started at least on the items mentioned below:

(i) Front-end converters at the UHF frequencies.

(ii) Solid state receivers for community viewers.

(iii) Inexpensive chicken mesh antennas for the community receivers.

(iv) Low noise amplifiers for earth stations.

(v) Low power transmitters for testing limited rebroadcast.

(vi) Primary power sources.

(vii) At least few components/parts of the transmit-receive chains.

In addition to the above developmental tasks quite a few research problems are also identified and most important amongst them are mentioned below :

(i) To propose a method after a successful theoretical analysis to arrive at an optimum method of transmitting and receiving multiple sound channels along with the video signal.

(ii) Optimum bandwidth requirements for one video and n audio channels.

(iii) UHF propagation studies (Theoretical before the start of the experiment and to verify these predictions later on) with reference to dispersive delays etc.,

(iv) Studies on modulation index optimization. (

v) Interference studies.

(vi) Optimum location of satellites from considerations of spillover and interference from side lobes.

(vii) Side lobe suppression techniques.

(viii) Threshold extension devices.

Though most of the above problems could be undertaken by the development groups in the country, it would seem appropriate to involve the universities and higher institutes of technology for the research problems mentioned.

The above list is not meant to be a complete one but is only an initial projection which requires immediate attention.

ANNEXURE 3

The revenue that could be earned by the use of the telecommunications capacity on the spacecraft :—

1.1. The longest eclipse generally expected on the synchronous satellite is of the order of 72 minutes and for some months such an eclipse will not occur at all.

1.2. For the operational coordination and house-keeping purposes etc. satellite time will be allotted and so considering 1.1 and 1.2 together it will be reasonable to say that the satellite is available only for 20 hours per day for telecommunications use.

1.3. The total capacity of the satellite will not be completely utilised as the utility will go down in the night and so it is the general experience that about 1/6 to 1/4 of the capacity will be considered to be utilised for full time.

1.4. Excluding the Sundays and holidays it can be expected that on an average the satellite will be used only for 300 days in a year.

1.5. Following rates are charged today for subscriber trunk dialling system :

Ahmedabad—Bombay	—	2.5 paise/second
Ahmedabad—Delhi	—	3.75 paise/second
Ahmedabad—Poona	—	3.75 paise/second

Even though direct dialling systems are not operating between Bombay and Delhi and Bombay and Calcutta, it is expected that such services will cost up to about 7.5 paise per second for the subscriber. Considering the time frame of 74-75 one can assume that these rates will go down and an average of *5* paise per second can be considered as the average which could be charged for the satellite service.

1.6. Out of the charge laid down for the trunk service, it is assumed that two-thirds of the costs or revenues are assigned to the trunk route while one-third of the revenue is assigned for the operations and the terminal equipment and the local exchanges.

1.7. Considering the points mentioned above one can work out the revenue that could be earned by the use of the tele-communications capacity on the spacecraft. For example in the joint study carried out by ISRO and General Electric Company, the satellite payload for 3600 telephone channels was considered. The revenue earned by such a system would then be :—

A.	Available time	20 hours per day
B.	Total seconds	7.2×10^4 seconds per day
C.	Total channel capacity	3600 channels
D.1.	l/6th capacity utilization	600 channels
D.2.	l/4th capacity utilization	900 channels

E.1. 43.2×10^6 seconds for which charge could be made for l/6th capacity utilization

E.2. 64.8×10^6 seconds for which revenue can be charged at l/4th capacity utilization.

F.1. At 5 paise per second the revenue earned would be Rs. 2.16×10^6 per day for one-sixth capacity utilization.

F.2. At 5 paise per second the revenue earned would be Rs. 3.24 x 10" per clay at l/4th capacity utilization.

G.1. Revenue earned per day for the l/6th capacity utilization by trunk route would then be two-thirds of (F.1) i.e. Rs. 1.44×10^6

G.2. Revenue earned per day for the l/4th capacity utilization by the trunk route would then be two-third of (F.2), i.e. Rs. 2.16×10^6.

H. Following the above analysis it represents a revenue earned of the order of Rs. 43 crores for 1/6th capacity utilization and Rs. 65 crores for l/4th capacity utilization per year.

I. This could be averaged to about Rs. 54 crores per year which represents a total earning of the order of Rs. 270 crores over the five year life-time of the satellite.

1.8. It has been mentioned in paragraph 1.3 that the total satellite capacity may not be fully utilized and hence consideration was given during the calculations that only l/6th or l/4th of the capacity will be utilized. However, with the television network also growing side by side the

same transponders which are used for tele-communication could be used for television distiribution whenever the satellite is not being fully utilized by the tele-communication services, particularly during the time period of 6.30 p.m. to 11.00p.m. and 7.00 a.m. to 9.00a.m. This distribution service could then be charged for and the revenue which might be earned by the utilization of the tele-communication facility on the satellite could be augmented by charging for the distribution service.

Questionnaire from LINK Newsmagazine answered by Chairman, AEC, for publication in their Annual Number - 15th August, 1970.

Q.1 What are the premises of your ambitious 10-year atonic energy development programme ?

A.1 I have discussed the basic promises of the Atomic Energy Commission's 10-year programme in my foreword to the recent AEC document entitled "Atomic Energy and Space Research - a Profile for the Decade 1970-80". If I may

quote -

"Nuclear power is today essential for economically supplying energy in large parts of the country, and is moreover the only major supply on which we will need to fall back in perhaps less than 50 years time. We, therefore, need to commit ourselves to an appropriate programme of atomic power stations. We cannot hope to gain all the great economic advantages of nuclear power unless we develop a mix of thermal and advanced. fact breeder reactors. It is ray firm belief that the problems of poverty and regional imbalances in our country cannot be effectively tackled without it.

Several uses of outer space can be of immense benefit to us as we strive to advance economically and socially. Indeed," without them it is difficult to see how we can hold our own in a shrinking world. The greatest cast/effectiveness of the uses of outer space occur through large scale applications rather than those of limited scope. A communication satellite can most effectively serve communities dispersed over large areas. Meteorological applications of satellites are likewise most relevant for a global system like the world Weather Watch.

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There might be many opinions concerning what would be an advantageous course to follow in the short run, but 10 or 20 years from now, when the population of India would bo somewhere between 750 ana 1000 millions, it can hardly bo controversial that we would need a very strong base of science and technology, of industry and agriculture, not only for our economic well being but for our national integration and for ensuring our security in the world. The profile of development, during the present decade, of atomic energy and space research carrying with it advances in fields such as metallurgy, electronics and instrumentation as well as computer sciences, has been fashioned to provide a viable future,"

Q. l(a) Have we acquired the necessary know-how to implement it ourselves ?

Q. l(b) Can we be reasonably self-reliant in respect of equipment and fuel components ?

A. I would make a distinction here between the concepts of self-sufficiency and self-reliance, Whether it bo in the field of technical know-how; or equipment and special materials. Self-reliance is certainly one of the principal objectives of the Indian programme, but this does not exclude our acquiring scientific and technical information from agencies outside the country, on terns, acceptable to us. Similarly, it may be necessary to import specific items of equipment or certain special materials which are not yet indigenously available. For example, although we have assumed full responsibility for the Madras Atomic Power Project, this still involves expenditure in foreign exchange to the extent of around 20 per cent. We would like to improve upon this in the future with growing capability of Indian industry. Exchange of scientific information and know-how on a basis of mutuality can be very beneficial all around and outside inputs can help us buy time if they are not a substitute for mobilising national effort on an effective scale.

In order to achieve the goal of self-reliance, it is necessary that we should give up the tendency to acquire 'black boxes' or complete systems from abroad but to grow a national capability.

Q.l(c) will nuclear power be really competitive with thermal power at least in areas far removed from coal mine heads ?

A. Even by 1960, it had been fairly soundly established that the cost of electricity from nuclear power stations was roughly equal to the cost of electricity from conventional thermal stations remote from the coal fields. The Energy Survey Committee appointed by Government in 1965 came to the came conclusion, namely that nuclear power was already competitive with conventional thermal stations situated more than 600 miles from a coal field.

While in areas close to coal mines the generation of energy can and should for the time being based on coal, large regions of the country are removed from deposits of coal by more than 800 KM, These regions constitute 35% of the country by area and 30% by population. With the exception of the eastern zone, they Include the principal communities engaged in activities needing energy in rapidly increasing quantities for industry as well as for agriculture. The transport of coal to these areas involves major investments on the transport system, for which the requirements of capital are large and the recurring economic penalty is substantial. Atomic Power clearly provides the most advantageous solution even with single units of 230 MWe a size small compared with units of 600 to 1000 MWe currently being installed in major atomic power producing countries.

Q.1 (d) Will there bo enough demnd to warrant the production of 2700 MWe by 1980 as you envisage ?

A. The Planning Comnissio's estimates of the growth of power by the end of the Fourth Five Year Plan lead to a total of 22,000 MWe. The annual growth rate of consumption of electricity in India during the first three Plans has been 12.6 per cent. Even assuming for the future a conservative growth rate of 12 per cent, the country will need by 1980 about 45,000 MWe of installed capacity. Our target of 2700 MWe of nuclear power represents only 6 per cent of this figure.

Q.1 (e) Since no major nation has gone in for the use of Thorium, have we developed the thorium technology well enough to stake a large outlay on it.

A. Thorium is a "fertile" material, that is it produces a fissile isotope of uranium when subjected to bombardment by neutrons in a reactor. Experimental and proto-type reactors using thorium are already in operation outside India and the results are very promising. This field is particularly relevant to India which has one of the easily available richest deposits of Thorium in the world.

Q. 1(f) There was a report that breeder reactor technology has come up against some major hurdle in France. How far is it practicable now ? Or is there any uncertainty about it still ?

A. We are not aware of any such development. On the contrary, France is currently constructing a 250 MWe fast breeder proto-type reactor. Other countries notably the U.S.S.R., Germany, U.K., Japan end the U.S. are quite active in this field. It is generally accepted that the technology will be fully commercial during the present decade and will usher in an era of inexpensive nuclear power generation surpassing what is possible with the present series of "thermal" reactors.

Q. 1(g) Will the programme give the country a real option on nuclear weapons ? This question is relevant because there seems to be some doubts about the thorium breeding by-product, U-233, being any good as a bomb material. (The U.N. experts' Committee which worked out the cost estimates of nuclear weapons in 1068 did not consider it necessary to take this material into account). A second point to be cleared is wether it is economical to combine power generation and weapons programme. Some serious doubts have been raised recently.

A. U-233 has always been recognised as a fissile material capable of use in weapons. The report of the Secretary General did not mention U-233 merely because Plutonium and U-235 were the more commonly known materials used for bomb production. We are not engaged in a programme of nuclear weapons and our plans can stand solely on economic considerations of national development and self-reliance. It must be recognised, however, that no non-aligned country can have a major defence capability, conventional or nuclear, without a real base of science, technology and industry.

Q.2 The Planning Commission has drastically cut your nuclear development programme -it has provided only Rs.15 crores for new projects in the fourth plan, Have you impressed upon the Planning Commission the need to restore the cut ?

A. The Atomic Energy Commission's proposals for the Fourth Plan period have been discussed in detail with the Planning Commission as well as at the highest level in Government. I believe that our programme will rot suffer for want of funds because it seeks to accomplish objectives which are meaningful to the nation.

Q.3. The Atomic Energy Commission is reported to have decided to develop its own gas centrifuge technology It is known to be a terribly complex and enormously costly process, Even Britain. France and the Netherlands are known to have pooled their resources for the purpose. In this light can we undertake to do it on on own especially since much of the work in this field is classified? How much will be the cost ?

3(a) Which other countries have this facility?

3(b) What is its relevance to our nuclear energy development programme since we propose to have our next generation of power reactors based solely on thorium - not on uranium ?

3(c) Or is it a weapon-oriented project?

A. 3. (a), (b), & (c) : We have decided to work intensively in the coning years to develop indigenously the gas centrifuge technology for the enrichment of uranium. Similar development is taking place in several countries of the world interested in the peaceful uses of atomic energy. The United Kingdom, the Federal Republic of Germany and the Netherlands concluded an Agreement last year for joint development of this technology to provide enriched uranium for atomic power plants.

The coat of an enrichment programme can be justified on purely economic considerations. Japan and Australia, two countries which have signed the N.P.T. have also announced their own national programmes for uranium enrichment through centrifuge technology. The use of slightly enriched uranium in thermal reactors results in substantial savings in capital costs and when interest rates are high, in the cost of atomic power as well. For example, the capital cost per installed KW of a 500 MW steam generating heavy water reactor (which uses enriched uranium) would be about Rs. 2000 as against Rs. 2500 for a CANDU (natural uranium) reactor of the same size.

In 1000, plants for the isotopic enrichment of uranium wore considered out of the question for India flue to their high costs as well as their enormous consumption of electrical power. This analysis was based on the use of the gaseous diffusion process. Since than there has been substantial progress in respect of the gas centrifuge process, which is less expensive to establish and appears to be within our national resources. However, since much of the work done in other countries in this field is classified, substantial research and development effort would have to be devoted to master the sophisticated chemistry and machine technology, as well as the production of materials which would be needed for this programme

Q. 4 There is an allegation that in drawing up your ambitious programme. you have not examined the question of priorities sufficiently carefully. Now far is it correct ?

A. I do not see where our priorities are inappropriate.

There is of course, scope for optimisation. For this purpose our plans may have to be continually up-dated and even the strategy altered as we proceed. But as I have stated in the foreword

> " ..... There are those who preach that developing nations must proceed step by step following the same process by which the advanced notions themselves progressed. One is often told that such and such a thing is too sophisticated to be applied. This approach disregards what should perhaps be obvious, that when a problem is great, one requires the most effective means available to deal with it.
>
> The seeming disadvantage of a developing nation such as India, which has only a limited existing technological infrastructure to build on, can be an asset rather than a liability. I suggest that it is necessary for us to develop competence in all advanced technologies useful for our development and for defence, and to deploy then for the solution of our own particular problems, not for prestige, but based on sound technical and economic evaluation as well as political decision making for a commitment of real resources. The traditional approach of planning to provide things like electric power or telecommunication services for a national infrastructure, based on projections of growth from past experience is inadequate. An alternative approach lies in creating consumption centres alongside facilities for supply; as for instance, an agro-industrial complex served by a large nuclear power station or a programme for television to the entire countryside using a direct broadcast synchronous communications satellite. Indeed there is a totality about the process of development which involves not only advanced technology and hardware but imaginative planning of supply and consumption centres, of social organization and management, to leapfrog from a state of backwardness and poverty."

Q. 5 You now want the country to go in for 500-KVe reactors, but is indigenous production capability large enough to meet the requirements of such giant reactors ? row do you propose to overcome the transporting difficulty? It is said that our roads and bridges at present will not be able to cope with the requirements of transporting the necessary machinery which will be enormously heavy.

A. Our Atomic energy programme is dependent on several factors external to our own establishments. Repeatedly, our projects have been faced with a situation where the absence of a long term estimate of the demands likely to bo made by the atomic power programme has made it impossible for major public sector undertakings or private units to plan their production and create fresh facilities. For example, it will clearly not bo possible for Bhopal to make a long tern commitment for the production of large sized turbo-generators or to effect economy involved in their manufacture unless we can indicate in advance the demand that is likely to arise for equipping such large power stations. Equally, it is imperative that industrial establishments in the country, which would be called upon to supply annually about 800 crores of equipment for all typos of power stations during the decade commencing 1975, should prepare themselves during the next 3 or 4 years with adequate design capability and trained personnel on the shop floor. A consortium of undertakings fully committed to the task of backing up the Atomic Energy Commission for the completion of future atomic power stations would also significantly reduce the heavy incidence of interest during construction and the consequent increase of capital costs of the projects.

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A major difficulty that has been experienced in the establishment of nuclear power stations relates to the inadequacy of the existing road and rail system to handle overdimensioned equipment. A 200 MWe station involves the transport of single pieces of nuclear components having maximum dimensions up to 27' x 24' x 20' and other equipment weighing upto 170 tonnes. There include shield tanks, calandrin, and shields, boilers, transformers and turbo-generator components. Over-dimensioned components and parts have to be transported from source locations like Power, walchandnagar, Bhopal, etc. The end shields for a 500 MWe CANDU type reactor will weigh about 32 tonnes. Experience no far as shown that unless steps are taken in advance for the creation of the infra-structure of road and rail transport, it will not be possible to handle such large sized equipment. The widening of roads and culverts, streng-thening of bridges, etc., Involve a considerable amount of work.

Q. 6 There seems to be a proposal by the Administrative Refoms Commission that nuclear research and space research are unrelated topics and hence should bo put under separate agencies. This is especially so because both are on the threshold of enormous expansion, requiring much closer attention. What is the reaction of the AEC ?

A. There are obviously several ways of organising these matters. It is not the organisation but the men in it and the operating culture that They carry which are crucial to success. The AEC has a proven record and an established tradition and morale to accomplish difficult tasks involving advanced science and technology. One should note that two of our major Public Sector undertakings, ECIL and UC II, have been sot up on the basis of AEC research and development, without dependence on foreign know-how or collaboration. The strength of the AEC organisation lies in bringing under one umbrella diverse advanced disciplines and technologies related to atomic energy and space research and organisations as well as men concerned with all aspects of the entire innovative chain - from basic sciences all the my to industrial practice and large applications - without interruption. We would he making a serious error if we effect organisational changes on grounds that can be supported neither on theoretical nor on practical considerations.

Q. 7 While recognising the achievements made in the field of electronics under the AEC, there is a feeling that some of the equipment produced are not as sophisticated no one would wise. What are the reasons and how does the commission propose to correct this short-coming ?

A. The first generation equipment produced by the Electronics Corporation of India Ltd., was designed several years ago at the Bhabha Atomic Research Centre, taking into account the need to maximise indigenous content based on components likely to be available in India. Solid state versions with performance characteristics matching sophisticated equipment have now started coming off the production line. These have been developed at ECIL.

SCIENCE POLICY OF GOVERNMENT

by

Vikram A. Sarabhai Chairman,
Atomic Energy Commission

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1. Two documents which are of inmdiate concern to us in discussing the Science Policy of Government are the Scientific Policy Resolution of 1958 and the Report of Cost on the Implementation of Scientific Policy. In my minute of dissent to the latter document, I have made the assertion that we know how to set about the task of applying R & D to real problems which face us. It is the purpose of the present note to explain in brief how we could set about doing so.

2. If we are "to secure for the people of the country all the benefits that can accrue from the acquisition and application of scientific knowledge" (Scientific Policy Resolution), we need first to consider individual sectors of our economy and identify products and processes which would be required ten and twenty years from now realising that the tangible fruits of what we do now can only start coming some three to five years later. R & D effort required to develop these processes and to design the products for indigenous manufacture can then be estimated in detail, along with requirements of scientific manpower. Choices between alternative paths would need to be made from the standpoint of estimated cost of R & D, of industrial effort and the benefits that can be derived. There might be many opinions concerning what would be an advantageous course to follow in the short run, but 10 or 20 years from now, when the population of

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Paper presented at the Third Conference of Scientists, Technologists and Educationists (C.S.T.E.) New Delhi - November 28-30, 1970.

India would be somewhere between 750 and 1000 millions, it can hardly be controversial that we would need a very strong base of science and technology, of industry and agriculture, not only for our economic well being but for our national integration and for ensuring our security in the world.

3. A time targeted technological plan of specific relevance to our national needs, with identified inputs of human and financial resources, is a pre-requisite to any meaningful mobilisation of resources. This plan prepared by groups of active scientists and engineers engaged in related fields should be subject to political decision making at the highest level. It is hardly necessary to emphasise that for projects which take five to seven years to complete, we have to look at least ten years in advance if our progress is not to be halting. 4. As an example of an exercise of this type we have the identification of the following specific major tasks in Atomic Energy:

a) 2700 MW of nuclear power to be commissioned before 1980. This means approval for four new power stations of 1700 MW for which construction should start during the Fourth Plan.

b) Design and construction of advanced thermal reactors of about 500 MW unit size which would lower the capital cost of power stations while still producing plutonium for our future needs in fast breeder reactors.

c) Completion of fast breeder test reactor and experience with technology of plutonium enriched fuel, its fabrication and reprocessing, sodium coolant technology and experience with thorium bred U-233 fuel.

d) Augmentation of heavy water production to about 400 tons per year to back up the programme for the use of natural uranium in our power reactors.

e) Design and construction of a large 500 MW prototype fast breeder test reactor.

f) Development of gas centrifuge technology for U-235 isotope enrichment. Development of special materials including carbon filament structures.

g) Development of the Narwapahar Uranium Mines and facilities for extraction from low grade ore.

h) Early completion of the Nuclear Fuel Complex to manufacture special materials and fuel elements for our programme.

i) Creation of adequate facilities for the reprocessing of irradiated fuel and recovery of essential by-products.

j) Widespread application of isotopes in industrial processing, food preservation, sterilisation and medical products, medicine and research.

Advances in science and technology are accompanied by rapid obsolescence of existing systems. Recognising that we do not wish to acquire black boxes from abroad but to grow a national capability, we should note that our plans have to be continually updated and even the strategy altered as we proceed. In many innovative tasks, forward planning and cost estimates can only be ad hoc and this has inherent limitations. There are many details, some technical in character, and others at a stage requiring further definition, which have perforce to be excluded in order that we can convey the broad outlines in terms of commitment of financial and human resources.

5. A similar exercise can be conducted on a wider canvas. Certain tasks can easily be identified today in which R & D effort would earn handsome returns. Most of the tasks relate to products and processes which would be needed by 1975 and are such that for success they do not require a scientific break-through but need only a goal oriented developmental effort. We have also included in this list certain tasks in which the success may not be so certain but in which success has very high benefits for the nation. The list below is not exhaustive but is merely indicative. The tasks are listed for some of the major sectors of our economy.

A• AGRICULTURE & FISHERIES:

1. Plant Breeding
2. Fertilizer Production Technologies
3. Plant Protection Chemicals and Entomological Controls.

4. Remote Sensing of Crop Diseases
5. Farm Equipment
6. Numerical Weather Prediction and Modification
7. Efficient Water Management
8. Technology for Desalination of water
9. Deep sea fishing
10. Food preservation techniques.

B. POWER

11. 500 MW Generators
12. Extra High Voltage Transmission Equipment
13. Reverse Flow Dump Turbines
14. Nuclear Reactors.

C. COMMUNICATION & ELECTRONICS

15. Communications Satellite
16. Electronics Switching for Telecommunications 17. Television
18. Medium Scale and Large Scale Integration Technology for Computer Manufacture.

D. TRANSPORTATION

19. Container Carrying Ships
20. Jet Engines
21. Rocket Motors
22. Inertial Guidance
23. Electrical traction.

B. MINERALS - METALS

24. Off-shore Drilling Technology
25. Earth Resources Survey including remote sensing from Aircraft and Satellites,
26. Advanced Manufacturing Technology for Ferrous and Non-ferrous Alloys.

F. FAMILY PLANNING

27. Drugs for Fertility Control.

6. The developed countries in the world devote more than 1% of their GNP to R & D. Unless all developed countries are allocating expenditures on research and development for non-economic considerations, their expected rate of return on R & D effort must be comparable to the rate of return that they earn in other investments. In countries which are OB the fore-front of technology and where skilled manpower is expensive the expected rate of return is likely to be lower than in a country such as India where skilled

manpower is comparatively cheap and where large areas of research and development are available which do not require fundamental breakthrough in science. Therefore we ought to be willing to increase our R & D budget to 1% of our GNP.

In 1969-70 with the GNP of Rs 31,733 crores our R & D expenditure was Rs 136 crores i.e. 0.43% of the GNP. Increasing this to 1% would have meant an additional expenditure of Rs 181 crores. With such an increase in expenditure, we would generate substantial employment and opportunities for creative and challenging work for our scientists and engineers. At roughly Rs 10,000 per year per person, this would have meant an employment for 180,000 people of which 36,000 would be qualified scientists and engineers, A large part of the expenditure on R & D goes into salaries and in real terms the resource cost is much smaller than the financial expenditure. With a total R & D expenditure of Rs 317 crores per annum spent on some 30 to 40 major tasks, one would be able to bring to bear sufficient concentration of effort on each task in order to gain an appropriate return in a time period of no more than five years from now. In a broad sense, about 50 to 60 per cent of this amount would go to design and development activities, about 30 to 35 per cent to applied research and 10 to 20 per cent to basic research. A significant part of the last would be spent in Universities and advanced institutes for research, contributing to the training of qualified scientists and engineers.

7. An essential ingredient for the success of a programme of the type outlined here is an organisation which permits an unbroken innovative chain linking up basic research at one end with commercial application at the other. "Science and technology" thereby becomes an integral part of each major national activity. It is for this reason that it would be wrong in principle to isolate science and technological R & D in a separate Ministry.

Moreover by broadly relating outlay on R & D in a particular sector to the contribution to GNP that the sector makes now, or is expected to make in the future, or the sectoral plan outlay, we can ensure that appropriate effort is devoted in each area.

8. Another ingredient for the success of the approach suggested here is one on which the Scientific Policy Resolution lays great stress. It is that scientists should be associated with decision making at the highest level. This is not achieved by giving them a role of advisers, but by placing on their shoulders overall responsibility for creating operating cultures within innovative organisations to deliver the goods. There would obviously be several alternative paths which one may in theory follow. Decision making by generalist administrators under such circumstances becomes particularly tortuous and irrelevant. The often heard statement that scientists cannot agree among themselves is merely an expression of the despair of the lay generalist arising from an inability to make a judgement himself and follow it through at all stages till the completion of the task. It is, in this context, particularly depressing that we are unable to implement quickly administrative procedures and organisational patterns appropriate to innovative tasks which have been evolved successfully in our own country. I believe we would make a big mistake to regard that the personnel and other practices evolved in the Atomic Energy Commission are not generally applicable to other R & D organisations. The vast disparity in the thinking of practising scientists and engineers and genera-list administrators in regard to these matters has become very evident from the manner in which the reports of the Committee of the Organisation of Scientific Research (COSR) are being implemented and from the difficulties

that arose within the Study Group on Scientific Departments of the Administrative Reforms Commission, which culminated in all Scientists Members refusing to sign the final report.

In conclusion, I urge that

a) We make a technological plan on the basic of a perspective projection of our national needs 10 to 20 years from now. This plan should be subjected to political decision making at the highest level.

b) We reduce the technological plan to specific initia tives/tasks that would need to be undertaken on a time targetted basis with the commitment of specified resources of personnel and finance.

c) Following the example demonstrated the world over of the cost effectiveness of R & D, we should not hesitate to invest upto 1 per cent of our GNP on some 30 or 40 major tasks in different sectors.

d) It is necessary to ensure that the innovative chain is not broken up and that a culture appropriate to inno vative tasks is provided. This should involve scientists and engineers in decision making at the highest level, not as advisers, but as those responsible for delivering the goods.

e) If the overall approach is acceptable, a start for implementing the proposals contained here can be made within three months and does not need to get bogged down in endless committees. There need not be a fear of immediately running into a serious problem of allocation of resources during the current plan. There is much fat in our present system and in any case it would be difficult to physically organise meaningful expenditure at a growth rate of more than 20% per annum. In consequence the additional allocation that may be required is about Rs 100 crores during the IV Flan period,

f) Formal organisational changes are not as important as working relationships between institutions and profes sionals, and these can be built round specific projects.

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IMPACT OF NUCLEAR TECHNOLOGY IN DEVELOPING COUNTRIES

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Abstract

The paper describes the manner in which nuclear technology has been accepted and developed in India for providing to the country a powerful impetus for development. New organisational structures, administrative practices and operating culture have evolved within the framework of traditional Government and Society for meeting the special needs of innovation in applying the peaceful uses of atomic energy. Direct benefits through providing nuclear energy economically in areas where other alternatives are less advantageous, viewing the long term needs of energy for the development of the nation and parallel applications of radiation and isotopes in diverse fields are evaluated. Examples are cited of the widespread implications to and involvement of the diverse agencies ana segments of national life in the peaceful uses of atomic energy in India.

The spin-off from specialised personnel training and practices as well as technology in the nuclear field to others such as desalination of water, electronics, metallurgy and, above all, application of scientific methods to problems of development are some of the indirect benefits which can permit a developing nation to leap-frog from economic backwardness. The paper deals with the infra-structure that is required for the applications of advanced technology and discusses the impact of national self-confidence and determination to progress.

The time constant for the growth of nuclear technology in a developing country-in relation to long range perspective planning, parallel support for fundamental, applied and developmental research, training of manpower and specialised industrial practices are identified as essential ingredients for success.

INTRODUCTION

The gap between the economically advanced and the developing nations is steadily growing. In the long run, this widening gap poses a threat to the security of the world far greater than the proliferation of nuclear weapons, the prevention of which has attracted so much attention in recent years. Can we now afford to ignore the urgent need to revise our approaches - national and international - to development? Should a developing country follow, step by step, the same path taken by countries now amongst the economically advanced nations or can it jump certain phases of technological development? Realising that when problems are large we need the best available means, should it rule out advanced technologies such as are involved in atomic energy, merely because the same solutions are either only concurrently being applied in the economically advanced nations or have yet to be tried out in them? Is the importation of black boxes from abroad adequate to ensure continuity of the developmental process? Is the traditional administrative culture of the Government appropriate to innovative tasks of development requiring advanced technologies?

We discuss here these questions, relating ourselves to experiences in India in undertaking atomic energy for development. We describe the relevance of atomic energy to India's development and the strategy followed in nurturing the growth of nuclear technology. Though we realise that in talking of developing nations there is no typical country, we have tried to identify the obstacles encountered in developing countries in adopting nuclear technology.

1. RELEVANCE OF ATOMIC ENERGY FOR DEVELOPMENT

Energy is an essential ingredient for increasing productivity in agriculture as in industry. The green revolution in India has resulted from three major inputs - new varieties of seeds, fertilisers and irrigation For all the three, atomic energy has a major contribution to make.

1.1. Nuclear Power

There are many circumstances under which nuclear power becomes essential, if inexpensive energy is to be provided. Hydro power

is usually the cheapest source of power. However, in India, with rainfall dependent on the monsoon and snow melt on summer, it fluctuates severely from time to time. For example, one of our biggest hydro electric projects is at Bhakra Nangal in Punjab. Though it is possible to provide from this project more than 350 MWe of power in 50 per cent of the years, in 10 per cent of the years the available power falls below 280 MWe. Thus, in these years it becomes necessary to shed power by as much as 20 per cent in a region populated by 30 million people. Moreover, hydro resources are not always available close to places where power is required. In many areas, as in peninsular South India, the limited hydro resources are fully utilised. When hydro power is limited, it is most economical to use it for peaking purposes and have alternative sources of power for base load.

The choice of the back-up would mainly depend upon the available sources of fuel, namely, coal, oil or uranium. If a country has any one of these resources, it would obviously concentrate on it. However, a country which does not have any of these would find it cheaper at today's international prices to import uranium as a source of energy. Even when a large country has abundant reserves of coal or oil, these reserves may be localised geographically, as in East and Central India. Thus, when the cost of transportation is taken into account in many parts of the country, uranium may provide the cheapest source of energy.

Regions which constitute 35 per cent of India by area and populated by almost 175 millions are located away from deposits of coal by more than 800 km. With the exception of the eastern zone, they include the principal communities needing, for industry as well as for agriculture, energy in rapidly increasing quantities with a doubling period of about five years. The transport of coal to these areas involves major investments on the transport system for which not only the requirements of capital are large but also the operating expenditure is substantial. In such situations, nuclear power clearly provides the most advantageous solution even with single units of 215 MWe (net), a size small compared with units of 600 to 1000 MWe currently being installed in major atomic power producing countries.

Over the past 20 years, there has been a steady escalation in the price of fossil fuels whereas uranium price has remained more or less constant. In India, the escalation in coal prices has been at a rate of around 3 per cent per year. In any case, fuel cost generally forme a smaller fraction of the total generating cost in a nuclear station than in a coal fired station. As a consequence when one looks at the economy of generation over the entire life time of a station, coal fired power stations suffer from an. additional disadvantage compared to nuclear power stations.

1.1.1. Cost comparison of nuclear power versus power from coal fired stations

A comparison of cost of power from nuclear and coal fired stations has recently been made. A discounting rate of 10 per cent and an escalation of 3 per cent in all annual costs *are* assumed. Two locations have been considered. One is close to pithead where the expected price of coal is about $5 per tonne and another is near Madras, which is representative of a location involving haulage of coal by rail over more than 800 kilometers and a price of about $11. 3 per tonne. For augmenting installed generating capacity by 215 MWe, a comparison is made between an extension to the Madras Atomic Power Project Unit-I, also of 215 MWe, and an extension to the coal based power plant of 300 MWe at Ennore nearby. For a 500 MWe size, new stations in both cases are considered. The capital costs of the stations reflect current experience in building new power plants with an indigenous content of about 80%. The present discounted cost; of power over 25 years from a coal based 215 MWe plant at Madras would be 12 per cent more than for a nuclear plant of CANDU PHW type. Near pithead, the coal based plant would be 10 per cent cheaper. However, for a unit size of 500 MWe, a coal based plant would be almost 50 per cent more expensive than a nuclear plant at Madras, while the two would be competitive at pithead.

India has four major regional grids which are expected to reach by 1980 a size exceeding 10, 000 MWe each, sufficiently large to accommodate power plants with single units of 50 MWe capacity. On the other hand, many developing nations may be confronted with the problem of the small size of their existing grids in order to derive full benefits from nuclear power. A way in which this handicap can be overcome is through the simultaneous setting up of consumption centres along with large generating units. An alternative that is sometimes available is to develop a power programme catering cooperatively to the needs of neighbouring countries. We give below examples of both these solutions.

1.1.2 Agro-industrial complexes

Detailed investigations of nuclear powered agro-industrial complexes have been carried out for two locations in India[1]. The studies are described in a separate paper[2]. Both complexes generate low-cost nuclear energy in areas where energy from coal-based plants would be more expensive. The energy is used for producing fertilisers and supplying water for irrigation, in such a manner that the required high load factor for the economic operation of a large nuclear power unit is provided. Inexpensive energy in both places makes possible the production of phosphorus using technology which substitutes imported sulphur. The energy is used in an arid location near the sea for producing desalted water and in the Gangetic Plain for lift irrigation. Comparatively large as the total investments are, the returns are spectacular.

TABLE I. PRESENT DISCOUNTED COSTS OF ALTERNATIVE POWER PLANTS

(Figures in Millions of US Dollars)

Item	Unit Size: 215 MWe (net)			Unit Size: 500 MWe (net)		
	Extension Nuclear Plant CANDU-PHW	Extension Thermal Plant		New site Nuclear Plant CANDU-PHW	New site Thermal Plant	
		Coal price			Coal price	
		$11.3 Te	$5.33 Te		$ 11.3 Te	5.33 Te

Figure 1 shows the details of the Gangetic Plain Project. The return on investment for the industrial portion including the power plant is expected to be 18%. For the agricultural portion, if efficient agricultural practices are followed, we can derive a return of 99% with bullock farming and about 119% with mechanised farming. Additional food production of 7. 8 million tonnes of cereals and 1. 66 million tonnes of pulses will result. This can meet the food requirement of about 30 million people. The programme would create all the year round direct employment on farms for about 1.4 million persons, and increase the gross national product by about 1,300 million dollars. Based even on conservative estimates of improvement in agricultural practices and yields, the additional food grain production will be 4. 0 million tonnes and the return on agricultural portion will still be more than 50 per cent.

These figures, dramatic and almost incredible, can be understood if we recognise that what we have in fact clone here is to use nuclear power, through the water that it pumps up and the fertilizer that it produces, for harnessing through photo synthesis the vast solar energy falling on the plains of India. With timely application of water and adequate fertilizers, the use of hybrid seeds results in a manifold increase in crop yields. The example provides a striking demonstration of the impact that energy can produce in our countryside where the vast majority of our under-privileged population resides. To realise the potentialities for accelerated development we need to clearly understand the role of energy and of water and adopt appropriate policies for their optimum utilisation.

1.1.3. Co-operative development

A study[3] was carried out for ECAFE in 1968-69 on the possibility of the development of power on a cooperative basis in the region comprising Singapore, West Malaysia, Sumatra and South Thailand. In Table II are shown the power requirements of the individual countries. It is clear that individually these countries would be able to install single units of only around 100 MWe each. For unconnected development of the four national grids, nearly 700 MWe of generating capacity will have to be provided between 1974-80. On the other hand, if a central plant is considered, a 500 MWe capacity station may be adequate, due to the economies possible from integrated operation of the four grids. The study recommends a central nuclear generating station of the Candu PHW type with two units of 250 MWe capacity each, the power from which at 5. 6 mills/Kwhr will be economical compared to an estimated 6.4 mills/Kwhr from a conventional plant. Assuming that nuclear fuel has to be imported, the foreign exchange required for natural uranium to fuel a Candu PHW reactor would be considerably less than for enriched uranium for fuelling light water reactors. The station whose output would be shared among the participating countries can be located at a site in Malaysia, such that the

TABLE II, POWER REQUIREMENTS OF INDIVIDUAL COUNTRIES (MWe)

Country or area	Existing as of end 1968		Planned for implementation for year 1969-73		Additional requirements for years 1974-80	
	Hydro	Thermal	Hydro	Thermal	Hydro	Thermal
Malaysia	264	274	Nil	420	252	270
Singapore	Nil	464	Nil	550	Nil	400
Sumatra	1.5	90.5	160	50	a/	a/
South Thailand	Nil	70	Nil	60	27	30

a/ There are preliminary suggestions that the Asahan hydro power project (Sumatra) with an installed capacity of 160 MWe (1974) be expanded by the additional 500 MWe; and a 200 MWe installed capacity thermal power station based on coal or lignite be set up near Palambang in Sumatra after 1974.

distance for transxnission to the three countries is minimised. If it is to be a dual purpose power and desalting plant, Singapore would be a preferred site,

1.1.4. Benefits from a nuclear power programme

The benefit of supplying nuclear power adds up to a very sizeable saving when a country's power programme is viewed in a broad perspective over a period of years. The expected growth of electric power and nuclear energy upto the year 2000 for India are discussed elsewhere.[4] By the year 2000, India will have roughly 4300 MWe of nuclear power, equivalent to about 30 per cent of the total installed capacity. The nuclear power stations can all be put up at distances more than 800 kms away from coal fields and in sizes larger than BOO MWe. In Table III we have calculated the savings from nuclear power over coal based power plants of same size. In terms of the present discounted value, the benefit accruing from nuclear power alone amounts to 1300 million dollars.

1.2. Benefits from Applications of Isotopes

Applications of isotopes are of great importance to developing countries whose economies are based primarily on agriculture. The estimation, using tritiated water, of under-ground water resources and the rate of their replenishment in areas such as the Gangetic Plain where extensive lift irrigation is proposed is of great practical importance. India has recently witnessed the dramatic economic impact of new strains of seeds. Use of irradiation for enhancing the capability of the the plant breeder is of major significance. Similarly, study of intake of fertilizers and of water by plants using labelled chemicals can lead to adoption of procedures for the efficient utilisation of both. Recognising the primary importance of these applications to agriculture, a joint IAEA/FAO/UNDP supported project entitled "Nuclear Research Laboratory in Agriculture" is now operating in India.

Even though only a few foodstuffs are currently cleared for unrestricted human consumption after irradiation, extension of the shelf-life of agricultural products such as bananas, onions and potatoes in ares where cold storage for these is not easily provided is of major economic importance. Based on a detailed feasibility study[5], an onion irradiator is to be installed in the onion growing district of Nasik in Western India. Irradiation will save most of the current sprouting loss which amounts to more than 25 per cent of the crop. An irradiator costing half a million dollars can process 48, 000 tonnes of onions per year on a 2-shift basis. The resulting saving of about 10,000 tonnes of onions is valued at $0.2 million. The internal rate of return on this irradiator is estimated to be 24 per cent.

TABLE III. BENEFITS FROM THE NUCLEAR POWER PROGRAMME OF INDIA

Year	Total Nuclear (10^3 MWe)	New Nuclear Plants commis-sioued. (10^3 MWe)	Saving[1] in dis-counted cost on the date of start of construction, (Million U.S. $)	Saving[2] discounted to 1970 (Million U. S. $)
1970	0. 4	0. 0	56	56
1975	1. 2	0. 8	264	164
1980	2.7	1. 5	527	204
1985	5. 7	3. 0	1000	239
1990	11.4	5. 7	1950	290
1995	*22. 5*	11. 1	3700	340
2000	43. 5	21. 0	-	-
Total				1293

1. A construction time of 5 years is taken. Savings obtained from Table II. Though from 1985 onwards fast breeders will become available, the savings have been computed on the basis of CANDU-PHW plants. This understates savings.

2. All the addition to capacity is assumed to take place at the end of the five year period. This also understates the discounted savings.

Radiation medicine is proving Invaluable for diagnosis and treatment of certain conditions. Its growth in most scientifically advanced countries has been very rapid. Its progress in developing countries, faced with undernourishment and disease, is handicapped through the inadquecy of trained man-power, unavailability of short-lived isotopes and absence of necessary equipment in diagnoistic clinics. In spite of these shortcomings, developing nations would find it worthwhile, as India has, to set up at least a few centres for radiation medicine in association with advanced medical institutions which can provide a national service.

For sterilization of medical products, irradiation has proven itself as a technique of choice for a wide range of articles. A UNDP/WHO assisted project in Bombay will soon establish a facility to demonstrate its economic advantages and the qualitative improvements that can follow from its use.

1.3. Potential Significance of Peaceful Nuclear Explosions

With nearly 1/7th of the world's population, India consumes roughly one per cent but produces less than 0.2. per cent of the copper output of the world. There are available in India large bodies of low grade copper ore of about one per cent copper content, which cannot be exploited economically by conventional means. A preliminary analysis suggests that it may be possible to exploit these economically using controlled under-ground nuclear explosions and in situ leaching. Realisation of this potential resource is dependent on the possibility of preventing harmful contamination of the environment, particularly aquifers. Similarly, economical recovery of nickel from low grade ores and oil (from shale) may be possible.

1.4. Spin - off Benefits

Successful execution of a nuclear programme requires innovation in so many areas that a new methodology for planning and for management becomes necessary. Problems have to be looked at as parts of a larger totality. In other words, a total systems approach is called for. Such methodology once introduced in one part of the economy starts to permeate rapidly in other areas.

An example of such a systems planning is the optimisation study[6] carried out for the Northern Electricity Region in India. For the first time the problem of providing additonal electricity generation capacity has been looked at not only from a quantitative standpoint of providing this capacity, but also the total systems cost involving a choice between specific alternatives of mix of hydro, fossil fuel and nuclear stations.

Attempts to maximise Indian components in nuclear power stations and other production plants have created an awareness in Indian industry of the need to work to stringent specifications and inspection standards. Industry is becoming conscious of its potentialities for excelence. Work in the field of nuclear fuel and materials has generated internal demands for superior materials of construction and for the means and methods of producing them to the standards required. Expertise developed in vacuum melting and casting of uranium and the sintering of uranium oxide has influenced the production of metals and alloys of controlled composition and to the progress of powder metallurgy. The techniques and facilities developed for the extrusion of zircaloy will find application in extrusion of alloy steel seamless tubes at the Nuclear Fuel Complex of the Atomic Energy Commission of India. A special plant at the Complex produces high quality materials for the electronics industry. The experience gained in the operation of highly instrumented plants in nuclear industry has created indigenous capability for the design and instrumentation of chemical plants. As a result of developing the vacuum technology of oil diffusion pumps, it has been possible to make blood plasma freeze drying equipment on the one hand and other freeze drying equipment for food and pharmaceutical materials on the other. Similarly, as a part of the AEC programme on Air Cleaning research, it has been possible to develop and successfully manufacture absolute air filters, which were till recently, imported from abroad. One can enumerate many such instances but perhaps the most important spin-off contribution of the atomic energy programme in India is the creation of an overall climate of self-confidence, self-reliance, a scientific temper and identification of national objectives which provides meaningful career opportunities for thousands of skilled engineers, scientists and technicians.

2. *STRATEGY* FOR DEVELOPING NUCLEAR TECHNOLOGY

2.1 Need for Self-Reliance

Once a. country has come to the conclusion that it needs the benefits of nuclear technology for development, it would need to choose the path it wishes to follow. Development is a process requiring a totality of effort and commitment on the part of a nation. The black-box approach involving an imported turnkey solution may be adequate and even beneficial in the immediate short run, but by itself does not provide sustained growth. The pace of scientific and technological advancement has brought in its wake rapid obsolescence. One-shot solutions which are possible with a turnkey approach therefore suffer from a basic defect of not containing within them the seeds for the ongoing development of technology for solutions to the problems of tomorrow. Our experience in other areas of our economy has shown that without indigenous research and development, self-reliance is not; possible. We quote the late Dr. Bhabha who has convincingly brought home this point[7]:

> "The steel industry has existed in India since the First World War, and one of the two steel plants was among the largest in the British Commonwealth in the early twenties. Yet, when these steel plants had to be expanded, it was necessary to draw upon foreign consultants and engineering firms to plan and carry out the expansion. When the Government decided to establish a steel plant in the public sector at Rour-kela, a German consortium had to be asked to undertake the job. For the next steel plant at Bhilai the same course was followed, this time, with Russian technical collaboration, The third public sector steel plant at Durgapur had similarly to be set up with the help of a British consortium, and essentially the same method is being followed with regard to the fourth public sector steel plant at Bokaro. Thus, the construction and operation of a number of steel plants has not automatically generated the ability to design and build new steel plants. Unless powerful scientific and engineering groups are established during the construction and operation of existing steel plants as a matter of deliberate policy, the dependence on foreign technical assistance will continue and the steel industry will not reach a stage of technical self-reliance. A similar situation exists in almost every other industry".

2.2. Self-Reliance Through Indigenous R & D

The Indian Atomic Energy programme is based on. the realisation that once a broad base of research and development is established, the indigenous capability for building and operating sophisticated plants gets created. In order to achieve it in the shortest possible time, a policy of leap-frogging was employed. Alongside the development of a basic infra-structure, cooperative programmes with countries which were more advanced in nuclear technology were entered into. Such cooperative programmes have helped in reducing the time required for research and development. They have provided at the same time opportunities to train in specific technologies, scientists and engineers who have later been made responsible for the implementation of specific programmes.

In reviewing the development of atomic energy in India three phases can be identified.[8]

The first, from 1944 to 1954, could be termed the formative phase. At the time of establishment of the Tata Institute of Fundamental Research in 1944, Bhabha already saw the long term perspective in practical terms. He then wrote:

> "When nuclear energy has been successfully applied for power production, in say a couple of decades from now, India will not have to look abroad for its experts but will find them ready at hand".

This phase saw the starting of scientific groups with a nucleus of competen scientists put in charge with a great deal of autonomy and freedom to carry out their work. The Tata Institute of Fundamental Research was heavily drawn upon for the initial support required for the Atomic Energy Programme.

The second phase between 1954 and 1962, saw the growth of the Atomic Energy Establishment at Trombay. This facility, now renamed Bhabha Atomic Research Centre (BARC), was planned to provide the basic infra-structure required for atomic energy in the country with special emphasis on problems of developing technology. Trombay has been a nursery where new developments have been continually nurtured.

The third phase which commenced around 1962 saw the utilisation for practical benefits of the knowledge and skills acquired. Emphasis was placed on the contribution to economic development through the setting up of atomic power projects, initially with foreign assistance but later without it, and industrial establishments based on the technology developed at Trombay. Nuclear power projects in Rajasthan and Madras, a Nuclear Fuel Complex and an Electronics Corporation in Hyderabad, a Uranium Corporation in Bihar, a Power Reactor Fuel Reprocessing Plant at Tarapur, the extension of activities of the Indian Rare Earths and the Heavy Water Project in Rajasthan are some notable examples.

2.3. Costs of Indigenous Development

In Fig. 2 are given the growth of scientific manpower, as well as the annual capital and revenue expenditures at BARC. These represent the bulk of the research and development expenditures undertaken in the past for the Atomic Energy Programme. In terms of percentage of GNP, the expenditure on development of atomic energy has grown from around 0.05% in 1958-59 to 0.06% in 1969-70. The present value in 1971 of the total expenditure during the past 15 years, compounded at 10 per cent, is 325 million U.S. dollars.

Recognising that this has enabled India to establish a sound base for design and construction of Candu PHW power reactors along with the support activities related to its fuel cycle and special materials like heavy water, we can relate the R & D expenditure to the benefits from a nuclear power programme involving only this type of reactors. This is of course a hypothetical assessment. For, in fact, looking to the need to augment domestic nuclear fuel resources, Fast Breeder reactors have to be developed in the current decade to reach an installed capacity of the magnitude contemplated. The total of 43,000 MWe of nuclear power by the year 2000 will consist of a mix of Fast Breeders and Candu PHWs. Though we neglect the economic advantages of a Fast Breeder compared to a Candu PHW, we still consider the additional R & D costs that we can

expect to incur in the next 10 years in order to develop a Fast Breeder Power Station upto the prototype stage. We estimate this cost to be 200 million dollars which when discounted at 10 per cent has a present worth of about 125 million dollars. Thus, for an expenditure on research and development of about 450 million dollars the expected benefit from the nuclear power programme alone equals 1,300 million dollars, as already indicated.

3. SOCIO-TECHNICAL FACTORS AND UTILISATION OF ATOMIC ENERGY FOR DEVELOPMENT

Though the uses of Atomic Energy are of major significance to developing countries, paucity of capital, lack of technical manpower, absence of an industrial infra-structure and difficulties of establishing an administrative culture suitable for innovative tasks may pose serious obstacles in their effective utilisation for development. To overcome these, it is necessary to look specifically at least ten years in advance if progress is not to be halting and results mediocre, since training of personnel and construction of major projects have an inherent time constant of five to seven years.

3.1. Scarcity of Trained Technical Manpower

The Indian Nuclear Energy Programme was started with the awareness that for its success scientific and technical manpower is the key factor. A decision was accordingly taken to establish and encourage advanced centres capable not only of providing trained manpower but also of acting as catalysts for the general scientific and technical development of the country. A school was started in 1957 at BARC to give special advanced training to graduate scientists and engineers required for the nuclear programme. During the past 14 years it has turned out about 1900 successful trainees who have provided the backbone of the ongoing atomic energy programme.

Unfortunately, not all developing countries have a broad base of professionally trained scientists and engineers, as in India. Only through advanced planning and determined effort this lacunae can be filled. Nations advanced in these fields can help in training the initial groups of scientists and engineers which can lay the foundation of a national programme.

3.2. Absence of Industrial Infra-Structure

Developing countries are handicapped by the non-availability of conventional technology and supporting institutions. In industrially advanced countries, nuclear technology entered the arena with a strong

base of conventional technology. On the other hand in India, the era of nuclear power is concurrent with the era of industrialisation, of growth of the steel and heavy engineering industries, of the installation of fertiliser plants and other conventional chemical industries, many of these with imported know-how. Nuclear technology, moreover, requires that it be supported by new technologies in a number of sectors. These include, among others, mining; special chemical processing involving in some cases highly corrosive materials; metallurgy of special alloys; high precision fabrication; fabrication of large and heavy equipment; electronics instrumentation and micro meteorology for contamination control. Successful execution of nuclear projects nationally requires innovation in many diverse sectors all at once. This can only be achieved progressively over a period of time.

3.3. Dual Role of the Government

Atomic Energy programmes and supportive national effort require substantial investments in scientific and technical manpower and of capital. These have generally to be made in most countries, at least initially, by Governments, which have traditionally been involved in providing stability but are now called upon to initiate change, two seemingly conflicting goals. They need at one end of the spectrum 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, they require 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.

The problem posed by these conflicting roles of Government is not insurmountable. The special role that Government has to play was recognised in the notification of the Government of India of 1958, on the constitution of the Atomic Energy Commission, which stated:

> "India should be able to produce all the basic materials required for the utilisation of atomic industry and build a series of atomic power stations, which will contribute increasingly to the production of electrical power in the country. These developments call for an organisation with full authority to plan and implement the various measures on sound technical and economic principles and free from all non-essential restrictions or needlessly inelastic rules. The special requirements of atomic energy, the newness of the field, the strategic nature of its activities and its international and political significance have to be borne in mind in devising such an organisation."

In establishing the institutions for the Indian Atomic Energy Programme, it was realised that concern shown, care taken and nurture given to people who have knowledge and skills, conveyed to them a sense of trust and the significance of their role in building society. Administration was organised largely as a service rather than a control function. It was accepted that in professional groups, scientists, engineers and others, motivation and control is largely inherent and contained in professional commitments. Hierarchical structures and systems need to be minimised and it is often necessary to spin off new institutions from existing ones, transferring not only expertise but a "culture" appropriate to the task. In the case of our nuclear centres, scientists and engineers who are entrusted with responsibilities are given sufficient powers to tackle the task efficiently. Responsibility and authority are then delegated right down the line.

3.4. Environment for Development

A constant interplay between the basic sciences, technology and industrial practice is essential if economic progress is to result from the activity undertaken. It is possible to develop atomic energy through basic, applied and developmental research in islands largely isolated from the rest of the country, but large scale applications for the benefit of the nation cannot be undertaken in isolation. Developing nations cannot have 20th century atomic energy with 19th century industry or antiquated systems of management and organisation. There is a totality about modernisation, and in order to gain confidence, they have to rise from an in-built culture within which a major departure from an existing well-proven system and anything which is innovative in character is automatically regarded with suspicion. Examples in several developing countries, including India, have demonstrated that this can be achieved given appropriate political and scientific leadership.

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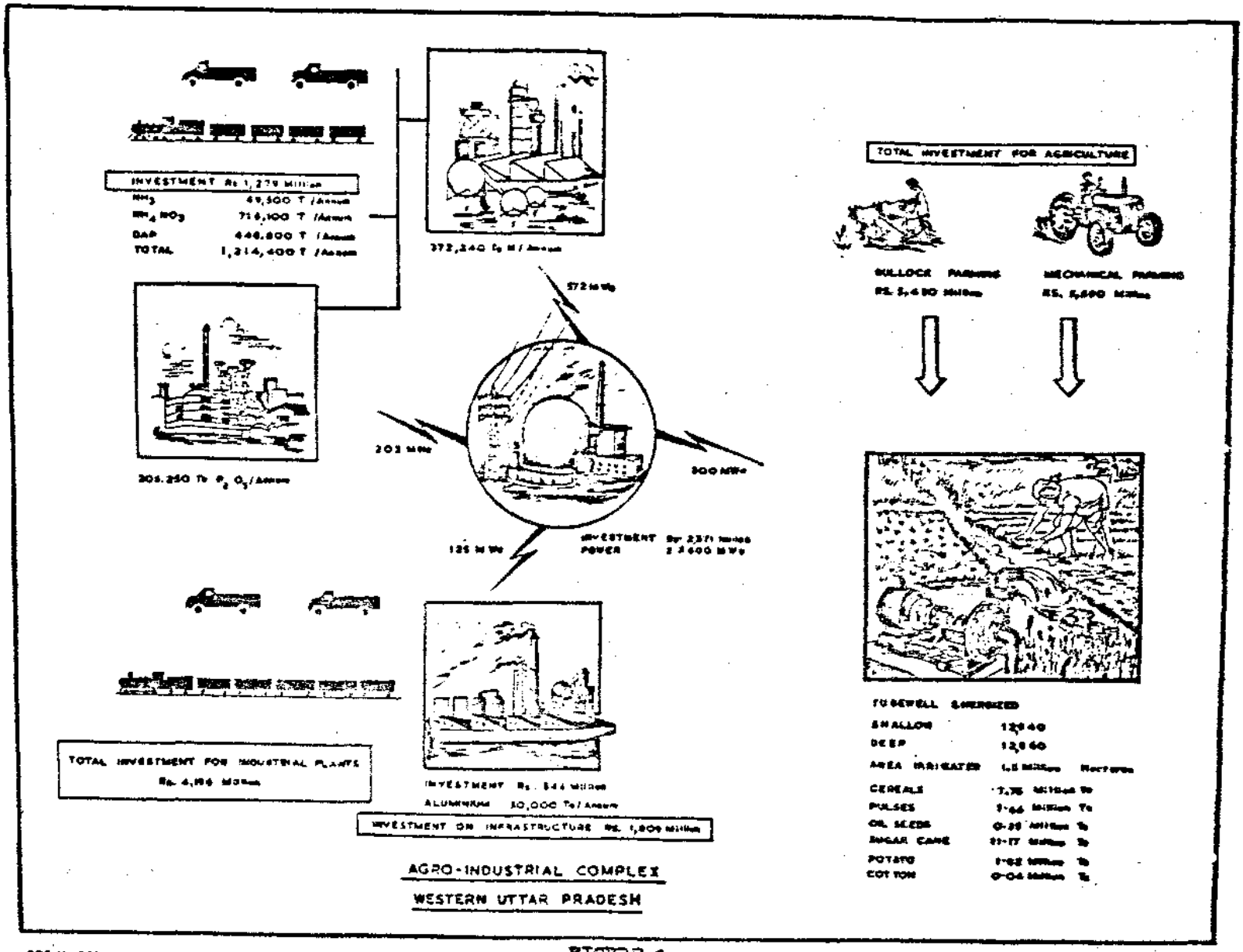

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FIGURE-1

GROWTH OF BHABHA ATOMIC RESEARCH CENTRE

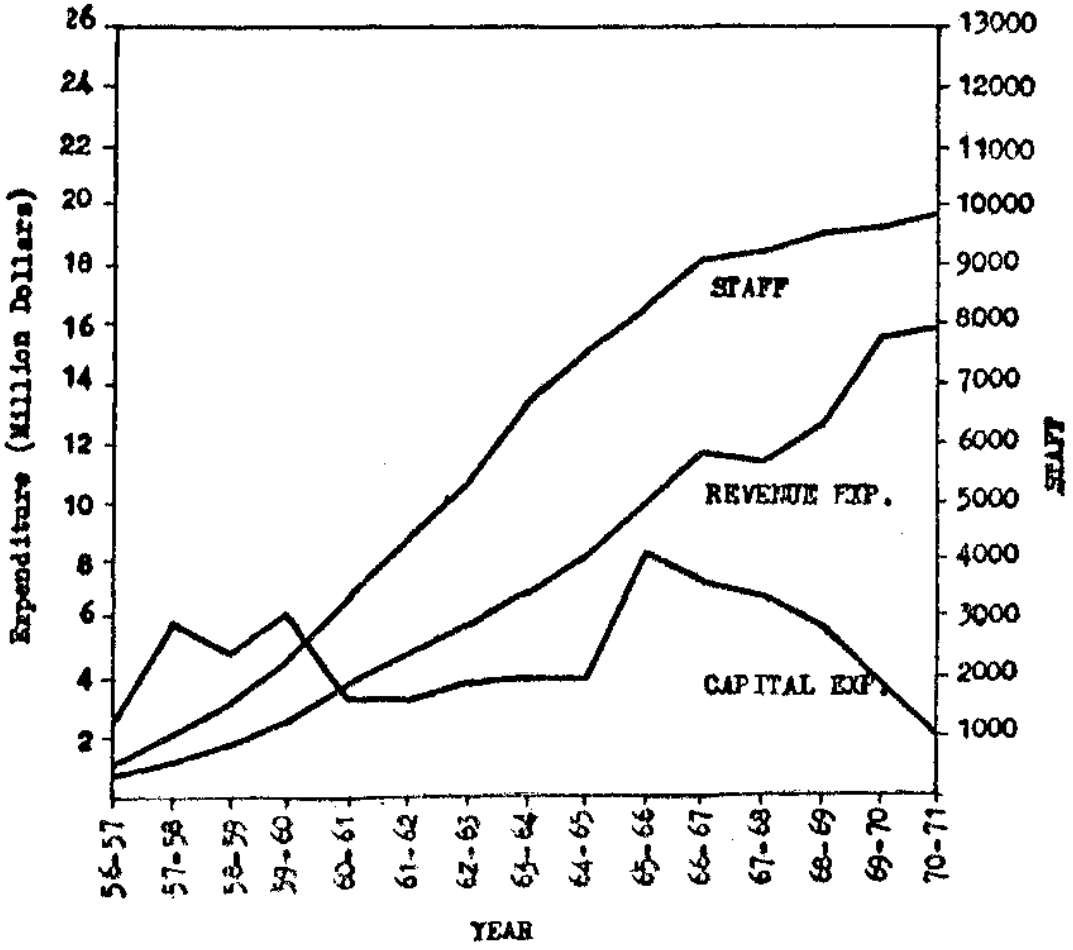

FIGURE - 2