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Chapter 31:

SCIENTIFIC AND TECHNOLOGICAL RESEARCH

ROLE OF SCIENTIFIC RESEARCH

Scientific and technological research makes a fundamental contribution to the development of a country. It has created better and more abundant crops, improved the health of people by cure and prevention of disease and provided speedier and better transport facilities by land, water and air and also more and diversified employment for the people. Atoms-for-peace and space exploration are its latest challenges.

2. High standards of living in the more advanced countries are the direct result of progress in science and technology and the rapid pace of development associated with it. The flow of new scientific knowledge is continuous and ever expanding and covers both pure and applied research. Pure research leads to new knowledge and understanding of nature and its laws, and creates the scientific capital from which practical applications of knowledge are drawn. New products and processes are based on new principles and concep[^]ons. The advance of technology presents new problems to science and also provides new tools with which to resolve them.

3. Siⁿre the Second World War, the pace of scientific and technological research in more advanced countries has greatly increased. In the economy of these countries, scientific research has an important and honoured place and receives every encouragement. As the field of enquiry and investigation widens, larger funds are invested, there is intens[^]e search for scientific talent, the number and quality of research workers improves, the pace of research is accelerated, and results are achieved with greater speed. One of the results of this activity in the more advanced countries, however, has been that the gap between the advanced and less advanced countries tends to become ever larger. The task before India is to cover this distance by putting in the utmost effort in the development of scientific and technological research, and in the application of science in the furtherance of her development programmes.

4. Investment in scientific research makes a large and enduring contribution to the prosperity of the country. As an instance, the remarkable development in the production of sugar and cotton in India may be mentioned, which is largely due to the application of the techniques of plant breeding. Apart from Government, it is industry which provides large resources for research in the more advanced countries. Industry supports research and in turn research advances industry and a symbiotic process is established.

In India the contribution of industry towards scientific research is not at present commensurate with the progress of the economy and the vast opportunities opened up through planned develop^s ment. Nevertheless, successive Five Year Plans have made steadily increasing allotments for scientific research. Through improvement in agriculture, medical and health facilities, techniques of locating and processing raw materials, providing substitutes and evolving new materials, appliances and techniques for industry, transport, power, communications and other essential utilities, investment in research yields a return many times over, Research will progressively reduce the burden of imports required for the maintenance of ex^stⁱng enterprises and establishment of new enterprises, facilitate exports and advance technical skills and know-how.

5. Aims of Scientific Policy.—The aims of India's scientific policy were set forth in Scientific Policy Resolution of March, 1958, in the following terms:

- i. to foster, promote, and sustain, by all appropriafe 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 scient[']sts of the highest quality, and to recognise 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 the discovery of new knowledge, in an atmosphere of academic freedom; and in general.
- vi. to ensure for the people of the country all the benefits that can accrue from the acquisition and application of scientific knowledge.

With the object of fulfilling these aims Government decided to offer good conditions of service to scientists, associate them with the formulation of policies and give them an honoured place in national life,

6. Research programmes.—In the First Five Year Plan attention was chiefly devoted to the building up of national laboratories and other research institutions. In the Second Plan the available facilities were developed, research was made more broad-based and research facilities in universities and at other research centres were further extended. In the Third Plan the programme of scientific and technological research will be devoted specially to—

- i. strengthening the existing research institutions and expanding facilities for re-research over a wide field;
- ii. encouraging basic research in universities;
- iii. encouraging, in particular, research in engineering and technology;
- iv. training of research personnel and expanding the programme of research fellowships and scholarships;
- v. carrying out research in the development and manufacture of scientific and industrial instruments;
- vi. coordination of research work carried out in national laboratories, universities, technical institutions, laboratories of scientific associations and research wings of Government Departments; and
- vii. utilising results of research after establishing their validity through pilot plant production, full scale field experiments, etc.

7. As a result of developments over the first two Plans an extensive network of institutions engaged in scientific research has come into existence and pure research, applied research and research in specialised fields are being undertaken at a large number of centres.

Research in pure sciences is being carried out mainly in the universities and in laboratories run by scientific societies and associations. The Council of Scientific and Industrial Research and the Department of Atomic energy encourage fundamental research in their own laboratories as well as in universities and in other institutions all over the country.

Applied and industrial research is being undertaken by national laboratories, cooperative industrial research associations and in a small number of industrial undertakings.

Research in engineering subject is being pursued in some of the national laboratories, in institutes of technology, in engineering colleges associated with universities, and in research agencies of Government Departments concerned with roads, railways, buildings, irrigation, power, communications, aviation, etc.

Research in mineral sciences is being undertaken by the Indian Bureau of Mines, Geological Survey of India, National Metallurgical Laboratory, Central Fuel Research Institute, Central Mining Research Station and the Oil and Natural Gas Commission.

Medical research is supported mainly by the Indian Council of Medical Research which coordinates and sponsors research schemes in a large number of centres.

Agricultural research is coordinated and sponsored by the Indian Council of Agricultural Research and the Commodity Committees and is undertaken at a large number of institutes and research stations maintained by the Central and State Governments.

Research and development work relating to atomic energy and isotopes is being conducted under the direction of the Department of Atomic Energy at the Atomic Energy Establishment. Energy at the Atomic Energy Establishment of nuclear research.

8. Resources for scientific and technological research.—Development expenditure in scientific and technological research and outlays for programmes in the Third Plan under the Central Government are shown in the following Table :

(Rs. crores)

Second Plan estimated	Third Plan
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	expenditure	
Council of Scientific and Industrial Research (C.S.I.R.) (including large scale field experiment) and Ministry of Scientific Research and Cultural Affairs	20-00	35-00
Department of Atomic Energy	27-00	35-00
Agricultural research	13-80	26-40
Medical research . *	2-20	3-50
Research under other Central Ministries (other than Defence)	9-00	30-89
total	72-00	130-00

The Third Plan outlays are in addition to expenditure amounting to Rs. 75 crores over the five year period on the continuance of facilities established upto the end of the Second Plan.

9. The progress of scientific and technological research over the first two Plan periods and the programmes formulated for the Third Plan are reviewed below under the following heads:

- i. Council of Scientific and Industrial Research,
- ii. Ministry of Scientific Research,
- iii. Department of Atomic Energy,
- iv. Research in agriculture and allied fields,
- v. Medical research,
- vi. other programmes of research:
 - a. irrigation and power,
 - b. transport and construction,
 - c. minerals,
 - d. communication,
- vii. sugar, jute and other industries,
- viii. research in universities and institutes of higher technology (including engineering research and statistics),
- ix. utilisation of scientific research,
- x. scientific instruments, and
- xi. standardisation, quality control and productivity.

II. COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH

10. Review of progress.—The Council of Scientific and Industrial Research undertakes research in its own laboratories and institutions, and also by way of sponsored research schemes in universities and other research institutions.

11. There are at present 23 national and regional laboratories which are mainly carrying on applied research. New laboratories started during the Second Plan include the Central Mechanical Engineering Research Institute, the Central Public Health Engineering Research Institute, National Aeronautical Laboratory and the Regional Research Laboratory, Assam. In addition, three existing laboratories namely, the Indian Institute for Biochemistry and Experimental Medicine, the Regional Research Laboratory, Hyderabad, and the Regional Research Laboratory, Jammu have been taken over by the Council of Scientific and Industrial Research. The Biria Industrial and Technological Museum has been established at Calcutta. The Council has also established the Central Indian Medical Plants Organisation for promoting cultivation of medicinal plants and the Central Scientific Instruments Organisation for developing the manufacture of scientific instruments.

12. At the national laboratories, surveys and assessment of raw materials have been undertaken and indigenous substitutes for scarce or imported raw materials have been developed. Improvements in manufacturing methods have been brought about and a range of new products have been developed. In this connection special mention may be made of the production of mica insulating bricks utilising waste mica, optical glass from indigenous raw materials, development of nickel-free stainless steel and coinage alloys, setting up of a low shaft furnace for production of iron from low grade ores and non-metallurgical coal on a pilot plant scale, multipurpose food. protein supplement food based on oil cakes and cereals, baby foods based on skimmed buffalo milk, dried fruit pulps, production of nicotine sulphate from tobacco waste, polyoses from tama-rin seeds, ion exchange resins from cashew nut shell liquid, decolorising and de-ionising carbons from low grade coal, building boards based on sawdust and other ligno-cellulosic waste, ceramic condensers, development of an automatic electronic traffic control device and group hearin'g aid for deaf children. Methods have also developed for upgrading coal, manganese ores and other minerals.

13. In addition to the national laboratories, the C.S.I.R. has established a number of research centres and units all over the country. There are about five research centres on essential oils for developing cultivation of essential oil-bearing plants, a Rain and Clouds Physics Research Unit and a Public Health Engineering Research Centre at Chandra'wal Water Works, Delhi. Research centres have also been set up for gas turbines, wind power, medicinal plants, earthquake engineering, etc.

14. The C.S.I.R. also sponsors research schemes at various universities and institutes and provides grants-in-aid for specific research schemes. The grants are given on the advice of 13 research committees of the C.S.I.R. which deal with different subjects. Universities, research institutes, industry and the Government Departments concerned are represented on these committees. During 1960-61, more than 360 research schemes were sponsored at 90 different centres.

15. A National Register Unit in the Council of Scientific and Industrial Research maintains up-to-date information regarding scientific and technical personnel in the country as well as a separate roster for Indian scientists receiving training abroad.

The Council of Scientific and Industrial Research has instituted a scheme for junior and senior research fellowships, which are tenable at the national laboratories as well as at universities and other institutions.

The Council of Scientific and Industrial Research maintains a Scientists' Pool which provides temporary placement to scientists returning to India after training abroad and assigns to them suitable work until they can secure opportunities in their own lines of specialisation. The strength of the Scientists' Pool has been recently raised from 100 to 200.

A scheme for providing financial assistance to retired research scientists to enable them to continue active research was instituted in 1958.

16. Industrial research.—It has been the policy of the C.S.I.R. to encourage research on problem of industries by cooperative research associations established by industries themselves. Thus, the Council has supported cooperative research units set up by the silk and art silk, rubber and paint industries and by the Textile Research Associations at Ahmedabad, Bombay and Coimbatore.

The national laboratories have endeavoured to assist various industries through provision of technical advice and testing facilities and investigations relating to substitute raw materials, etc. Contacts are maintained with industrial associations, Chambers of Commerce and technical departments of the Central and State Governments with a view to identifying problems and referring them to the appropriate national laboratories or further study. Industrial liaison offices have also been established for keeping in touch with the industry.

17. Programmes of national laboratories.— Each national laboratory has reviewed its work and drawn up a programme of development for the Third Plan. A few leading items in these programmes may be briefly mentioned. The National Physical Laboratory will undertake development of radio components on a pilot plant scale. The National Chemical Laboratory proposes to set up new Divisions for dyes and inorganic intermediates and essential oils and will undertake a number of new pilot plant projects. The National Metallurgical Laboratory will establish a new Division for alloy steels as also to study problems of corrosion under different conditions. The Central Fuel Research Institute will extend its work on the utilisation of low grade coals and will initiate large scale pilot plant trials. The Glass and Ceramic Institute will have a pilot plant for the production of optical glass and a separate wing for research in mica products. The Central Drug Research Laboratory will start a Division for antibiotics and fine chemicals. The Central Food Technological Research Institute will establish regional fruit and vegetable preservation stations. The Central Road Research Institute will set up a new Division for the study of problems relating to bridges. The Central Building Research Institute proposes to start five regional research units. Regional extension centres will also be set up by the Central Leather Research Institute. The Central Electro-Chemical Research Institute will have new Divisions for research on corrosion and chemical physics. The Central Salt Research Institute will undertake work on algology and will also initiate pilot projects for the recovery of by-products from salt bitterns.

The Indian National Scientific Documentation Centre (INSDOC) will be expanded to serve as a national clearing house for scientific and technical information.

Among the institutions begun during the Second Plan reference may be made to the Central Mechanical Engineering Research Institute at Durgapur, the Central Public Health Engineering Research Institute at Nagpur, the National Aeronautical Laboratory at Bangalore, the Regional Research Laboratory in Assam, the Central Indian Medicinal Plants Organisation and the Central Scientific Instruments Organisation. These institutions will be fully equipped in the course of the Third Plan.

18. New research institutions in the Third Plan.—A number of new institutions and research centres are proposed to

be established in the Third Plan. These include, amongst others, the Institute of Petroleum, the National Biological Laboratory and a Regional Research Laboratory.

The Institute of Petroleum for research on petroleum and its products is being established at Dehra Dun.

It is proposed to set up a National Biological Laboratory with Division for physiology, cytology and genetics, experimental embryology, microbiology, virology and immunology, biophysics and biometry, and biochemistry.

It is proposed to establish a Fire Research Station along with the Bombay regional unit of the Central Buildings Research Institute, Roorkee. The Station will undertake research on fire problems and will advise on problems relating to fires and fire protection.

For studying the effects of earthquakes on structures and for designing earthquake-proof constructions, the Earthquake Engineering Research Centre, set up during the Second Plan at Roorkee, is to be strengthened.

The pilot plant of the Low Shaft Furnace Project established at the National Metallurgical Laboratory, Jamshedpur, to carry out trials for the production of iron without using coking coal, will be expanded to include the production of ferro-alloys. The scope of the project will also be extended to utilise the low shaft furnace gas for upgrading low-grade manganese ores and for the production of sponge iron.

Proposals to establish during the Third Plan cooperative research associations for automobiles, cement, foundry, printing, food and allied industries are being examined.

III. MINISTRY OF SCIENTIFIC RESEARCH

19. The Ministry of Scientific Research is responsible for the development of several research organisations, such as the Survey of India, the National Atlas Organisation, the Botanical and Zoological surveys and the Central Board of Geophysics and also makes grants for scientific research.

20. Surveys of India.—During the First and Second Plan periods 1.66 lakh sq. miles of the country were covered by departmental surveys on standard scales. In addition, demarcation of the boundary between West Pakistan and India was largely completed. Surveys covering about 110,000 sq. miles in connection with more than 150 river valley, flood control and industrial projects were completed by the Survey of India. Surveys by photogrammetric methods have also been introduced. The Survey of India participated in observations under the programme of the International Geophysical Year. To cope with heavy demands for surveys and mapping for projects under the Five Year Plans, the Survey of India has undertaken a scheme of expansion, mechanisation and modernisation. During the Third Plan the Survey of India proposes to set up separate research cells for cartography, geodesy and photogrammetry.

21. National Atlas Organisation.—The National Atlas Organisation, which was sanctioned in 1956, has a large programme of work in hand. It has produced a preliminary edition of the National Atlas of India in Hindi and is engaged in the preparation of the main edition. The Organisation proposes to bring out maps in the form of fascicules in respect of various topics, such as population, physical, transport, etc.

22. Botanical Survey of India.—The Botanical Survey of India has formulated a programme of development for the Third Plan which includes the setting up of Divisions for economic botany and medicinal plants, a national cryptogamic collection which will include marine and fresh water flora, a central pool for wood, pollen, fossil and corpalogical collection and experimental gardens in different climatic regions. It is also proposed to develop further the Indian Council of Ecological Research so that problems relating to desert control, flood control, soil conservation and wild-life management may receive further attention. The Botanical Survey proposes to constitute two new Circles in the Third Plan. One of these will be concerned with the problems of the arid zone.

23. Zoological Survey of India.—During the Second Plan important faunistic surveys were undertaken by the Zoological Survey. These included the Rajasthan desert survey, Sambhar Lake survey and Pondicherry-Karaikal surveys. Several thousand specimens were collected, studied, identified and added to the national zoological collections. Development schemes of the Zoological Survey for the Third Plan include the establishment of new Divisions for ecology and wild life conservation and palaeozoology and of two new field stations for conducting research work on fresh water and high altitude biology. The Marine survey Unit will also be expanded.

24. Central Board of Geophysics.—The Geophysical Research Wing and the Oceanographic Research Wing which were started by the Central Board of Geophysics during the Second Plan period are still in their initial stages. The Council of Scientific and Industrial Research will take them over from the beginning of the Third Plan. The Geophysical Research Wing is concerned with various aspects of geophysical exploration and instrumentation.

The Oceanographic Research Wing will collect oceanographic data over extensive areas in the Arabian Sea and Bay

of Bengal. It will also participate in the International Indian Ocean Expeditions (1960-64).

25. Assistance for scientific societies and associations.—Scientific societies and associations maintain research institutions of their own and offer scholarships and fellowships to promising young scientists. In the Second Plan, the Ministry of Scientific Research provided about Rs. 2 crores as grants-in-aid to scientific societies and associations. Among the organisations which have been assisted are the National Institute of Sciences of India, the Indian Science Congress Association, the Indian Association for Cultivation of Science, the Bose Institute, the Indian Academy of Sciences (Raman Institute), the Physical Research Laboratory (Ahmedabad) and the Birbal Sahni Institute of Palaeobotany. Assistance is also given to a number of other learned scientific societies in fields such as physics, chemistry, mathematics, botany, zoology, geology, mining and engineering.

26. During recent years there has been a new interest in the country in mountaineering and striking advances have been made since the establishment of the Himalayan Mountaineering Institute at Darjeeling. During the Third Plan mountaineering research and expeditions will be given the support needed.

At the end of the Second Plan a Himalayan Zoological Park was established at Darjeeling. It will be developed further during the Third Plan.

27. Vijnan Mandirs.—The object of the Vijnan Mandir scheme (rural science laboratories) was to create popular interest in scientific development, disseminate scientific information and bring application of science closer to the everyday life of the rural population. By the end of the Second Plan 39 Vijnan Mandirs were set up. The working of the scheme has been reviewed by a committee which has suggested that Vijnan Mandirs should function in close cooperation with educational institutions and popular organisations in areas served by the community development programme and that their administration should be taken over by State Governments. These proposals are under consideration. Tentatively, it is envisaged that 160 additional Vijnan Mandirs should be set up in the Third Plan.

IV. DEPARTMENT OF ATOMIC ENERGY

28. The principal aims of the Department of Atomic Energy are to develop the use of atomic energy for the production of electrical power, and to develop its uses in agriculture, biology, industry and medicine through a widespread use of isotopes as tracers in scientific investigations and as sources of radiation. Since India has the largest deposits of thorium in the world, the ultimate aim is 'to base nuclear power production in the country on thorium, a task which will require long range research and the solution of many difficult technological problems in physics, chemistry, metallurgy and engineering.

29. Atomic Energy Establishment.—The principal centre for scientific research and technical development work in the field of atomic energy is the Atomic Energy Establishment at Trombay which was inaugurated in January, 1957. It has at present on its staff over 1300 graduate scientists and engineers who have been given advanced on-the-job training in the Establishment. The work of the Establishment is organised in some 15 Divisions covering scientific disciplines such as physics, chemistry, biology, medicine, engineering and metallurgy.

The Physics Group comprises the Nuclear Physics, Health Physics and Electronics Division and the Technical Physics Section. The Nuclear Physics Division is doing important work on the diffusion and slowing down of neutrons in various materials, which is necessary for an understanding of basic physical phenomena in solids as also in the design of nuclear reactors. Work on neutron scattering and other nuclear reactions is being undertaken.

The Air Monitoring Section of the Health Physics Division not only monitors the air at several important places in the neighbourhood of the Trombay Establishment but also has established 34 centres in different parts of the country for undertaking systematic survey of radio-active content of air, rain-water and milk, thus enabling a check to be kept on fall-out due to atomic explosions. Measurements are also carried out on the radio-active content of vegetation especially in the neighbourhood of Bombay and also of the strontium absorbed in bones, in animals and human beings, due to ingestion of radio-strontium arising from atomic fall-out.

The Electronics Division has developed almost all the electronic instruments used in the Atomic for all workers dealing with radiation and radioactive substances in the Trombay Establishment, and also on a voluntary basis for hospitals and research institutions in the country.

The Electronics Division has developed almost all the electronic instruments used in the Atomic Energy Establishment and for the survey of radioactive minerals. The programme of production is being expanded to meet the country's entire requirements of electronic instruments for the Third Plan. The control systems for Apsara and Zerlina Reactors were developed by the Reactor Control Section which is now in a position to produce the control system for any reactor including a nuclear power station.

The Technical Physics Section is engaged in developing and making instruments which have been imported hitherto.

Several different types of mass spectrometers as well as other instruments have been designed and produced.

30. The Chemical Group consists of Divisions for Analytical Chemistry, Isotopes, Radio-chemistry, and Chemical Engineering and a Remote Handling Section. This Group has developed techniques for detecting minute quantities of impurities in atomically pure material; for example, boron can be detected to a tenth of a part per million in graphite. Techniques for the production and handling of radioisotopes and for handling and treating highly radioactive substances such as radio-iodine, radio-phosphorus, radio-gold, radio-sodium, radio-iron, etc. have been developed for facilitating their use for research or in therapy. Important work has been done on studying the chemical properties of plutonium and the rare earths for developing industrial processes for separation of plutonium and rare earths from used fuel elements. Research and development work has been done for producing atomically pure uranium from crude uranium salt and on the basis of this work a pilot plant has been successfully designed and built and has been in operation since April, 1959. This plant has produced the uranium which fuels Zerlina and the Canada-India Reactor. Processes and flowsheets have been worked out for the uranium mill to be set up in Bihar for the extraction of uranium from uranium ore. A process has been developed for the extraction of minute amounts of uranium from waste copper tailings and is being tried out on a pilot plant scale. Pilot plants for making stable isotopes such as nitrogen 14 have been set up. Considerable work is being done on different methods of making heavy water and on upgrading heavy water which becomes downgraded in the course of operation of atomic reactors. Basic research concerned with developing uranium, thorium and other alloys of importance in atomic energy work, is being carried out in the Metallurgy Division. The Division has been responsible for designing, building and operating a facility for the production of elements. The establishment of uranium metal and fuel fabrication plants has placed India among the few countries which produce their own fuel elements.

31. The Engineering Group consists of three Divisions, namely, Reactor Engineering, Re-actor Operations and Engineering Service, and is concerned with engineering problems relating to the design, construction and operation of atomic reactors. It has designed and built seven "loops" for studying the behaviour of materials used in reactors. The Group was responsible for the mechanical and engineering design of Apsara and Zerlina.

Apsara became critical on August 4, 1956, and gave continuous and trouble-free operation for four years till it was shut down on August 4, 1960, for maintenance, repairs and renovation. This reactor has operated for 2.2 million kWh in four years and has produced most of the radioisotopes made in India and has also been a valuable tool for experiments in physics. It has been in operation again since January, 1961, with an improved control and cooling system. Zerlina went into operation on January 15, 1961. The Canada-India Reactor is a high flux, natural uranium fuelled, heavy water moderated, light water cooled reactor, which first became critical on June 16, 1960. This is a powerful reactor for engineering research and provides a necessary facility for the design of nuclear power stations. It is also one of the largest potential isotope producers and will make India self-sufficient in pile-produced isotopes, including specially those used for medical purposes like radio cobalt,

32. The Biology and Medical Divisions have done important work on the effects of radiation on biological organisms especially at the cellular level.

33. The Tata Institute for Fundamental Research, which was established in 1945, is the leading centre for advanced study and fundamental research in nuclear science and mathematics. Research work done by this Institute in theoretical physics in the field of elementary particles, its experimental work in cosmic rays, geophysics, nuclear physics and its school of mathematics have received wide recognition. The fundamental work in mathematics, cosmic rays, geophysics and nuclear physics will be developed further. It is proposed to instal one of the latest types of fast transistorised digital computers in the Institute. It is also planned to design and build a computer with a higher speed and more powerful computational facilities than any commercially available today. A charged particle accelerator for high energy nuclear physics work is also under consideration.

34. The Department of Atomic Energy has a large Atomic Minerals Division whose function is to find new deposits of minerals of use in an atomic energy programme. Thorium deposits containing nearly 300,000 tons of thorium in a concentration of 10 per cent were discovered in Bihar. A number of finds, which are in the process of being proved by drilling have also been made in the country. One of the deposits in Bihar contains several thousands tons of uranium. India has also important deposits of beryl, zircon, and other minerals of importance in the atomic energy programme.

35. Programmes in the Third Plan.—During the Third Plan the Atomic Energy Establishment will intensify and broaden the scope of activities which have been described above. The present temporary laboratories will be replaced by new laboratories. These will include, in particular, a Modular Laboratory for housing the Divisions which will handle only small quantities of radioactive material and a large Radiological Laboratory for high activity work with hot cells, in which hundred thousand curie amounts can be handled, as will be necessary for the Isotope and Radiochemistry Divisions, and the plutonium laboratory.

36. Some of the more important developments envisaged in the Third Plan may be briefly mentioned. The film badge service of the Health Physics Division will be extended to cover all institutions in the country using radioactive

materials or radiation.

The Electronics Division will expand its work on design and production of electronic instruments. The Division has also taken up the development and manufacture of transistors.

A plant for the treatment of used fuel elements and the extraction of plutonium is under construction at Trombay, and will be completed in the first half of 1963. The plant is also designed to treat uranium fuel elements enriched upto about 2 per cent, and will provide the experience necessary for the construction of the plutonium plant proposed for the Third Plan. Extensive waste disposal facilities are an essential part of a large atomic energy establishment, and a waste treatment plant for high active waste is being designed in conjunction with the plutonium plant. A plant for treating low active waste will be constructed next to the Canada-India Reactor.

Processes for the production of zirconium, beryllium, and other metals required in an atomic energy programme have already been developed during the Second Plan. These will be tried out on a pilot plant scale.

37. The Isotope Division will increase its production of radio-isotopes, such as, phosphorus 32, sulphur 35, chromium 51, iron 59, bromine 82, iodine 131, and gold 198, so as to be able to supply the needs of the entire country. In addition, the production of labelled organic compounds necessary for biological investigations, which has already been initiated, will be greatly expanded.

The production of large quantities of cobalt 60 for medical therapy will be established, so that this radiation source, so valuable in the treatment of cancer, can be supplied to many more hospitals in the country than at present.

A medical Isotope Centre will be set up which will provide for the use of isotopes in medical research and therapy, and for the training of doctors from all over the country in the use of these new tools.

The Biology Division and the Medical Division will be greatly augmented with increased effort on the study of cancer, chemical mutagens, and anti-cancer agents. The construction of a gamma field at Trombay for using radiation to study and produce plant mutations and to develop species with better characteristics will be completed.

Work on preservation of food by radiation and on sterilisation by radiation of such articles as bandages, medical equipment, etc. will also be taken up.

38. A study is being carried out of the cost of a 200 MW nuclear power station of Canadian type using heavy water as moderator and organic as coolant.

Work on a 20 MW prototype nuclear power station using natural uranium as fuel, heavy water as moderator, and organic as coolant will be carried further.

39. The high altitude laboratory at Gulmarg will be completed and connected by a wire ropeway to a higher station at Khilanmarg and Apharwat. These laboratories will be used immediately for high altitude research in cosmic rays, but will also be available for high altitude research in biology, physiology, and other sciences.

It is also planned to set up a high altitude laboratory at Kodaikanal in South India on the magnetic equator at an altitude of nearly 8000 feet.

40. The Atomic Energy Establishment, in cooperation with the Tata Institute of Fundamental Research, maintains a training school to which some 200 post-graduate students are admitted every year from universities all over the country. In the Third Plan, the training school will provide for facilities for a larger number of post-graduate scientists from Indian universities as well as for a limited number of scientists from other countries. The Department of Atomic Energy has instituted a scheme for the award of 120 scholarships every year to undergraduate and post-graduate students in the universities with a view to encouraging bright students to take up scientific careers.

The Department proposes to set up two inter-university centres—one in the north and another in the south—for providing scientists in universities with research facilities requiring the use of experimental reactors and other large expensive equipment.

V. RESEARCH IN AGRICULTURE AND ALLIED FIELDS

41. Agricultural research is carried on in Central research institutes as well as at research stations in the States. Besides, the Indian Agricultural Research Institute, Delhi, the Forest Research Institute, Dehra Dun, the Indian Veterinary Research Institute, Izatnagar and the National Dairy Research Institute at Kamal, fundamental studies and research are undertaken at Central Research Institutes for rice, potato and fisheries. Research on local problems is carried on at a large number of research stations which are assisted by the Indian Council of Agricultural Research

and Commodity Committees for Cotton, Jute, Oilseeds, Tobacco, Sugar-cane, Arecanut, Coconut and Lac. Research on plantation crops is sponsored by the Tea, Coffee and Rubber Boards. The Indian Council of Agricultural Research and the Commodity Committees also assist for coordinated research projects of a regional or all-India character. An important development in the Second Five Year Plan is the setting up of 17 composite research stations on cotton, oilseeds and millets. The establishment of these research stations has provided a coverage for fundamental research applicable to a wide range of agro-climatic conditions. Research on soil conservation problems is undertaken under the auspices of the Central Soil Conservation Board.

42. Agriculture.—Over the past decade agricultural research has contributed to improvement in crop production in several directions. Among these mention may be made of the development of rust resistant wheats at the Indian Agricultural Research Institute. One of these wheats was produced using atomic energy as a source for inducing mutations. During the First and Second Plans research has been undertaken in the breeding of high yielding varieties of rice, introduction of new varieties, improvement of hill paddy, and evolution of rice varieties resistant to disease. Fundamental studies on the physiology of rice plants have also been carried out. In respect of millets, the technique of hybridisation is being extended to jowar and bajra with a view to evolving high yielding varieties. At a number of stations improved agronomic practices relating to millets are also under study. In the field of cotton research, the acclimatization of sea island cotton of Andrews variety in Kerala is a significant development. Extra long staple cottons have been evolved in Madras and Punjab and recommended for commercial cultivation. A large programme of hybrid maize seed production has been taken in hand. Several improved varieties of subsidiary food crops like tapioca and potato, vegetables such as tomato and brinjal, and fruits like grapes and papaya, and of pulses and oilseeds have been evolved. Dosage rates of fertilisers for different crops and their water requirements have been worked out. Work on weed control and control of diseases and pests by chemical spray has yielded useful results.

43. For the Third Plan, the Indian Council of Agricultural Research has a programme for enlarging facilities for research in the States through expansion of the existing agricultural institutes and by the setting up of experimental stations in different regions based on soil and climate. Rice research stations with sub-stations will be set up in each rice growing State. Research on wheat rust control and other coordinated agronomic experiments and research on hybrid maize will be extended. Cross-commodity stations for research on millets, cotton and oilseeds will also be expanded. Agricultural research centres will be established in each major river valley project area and agronomic surveys of those areas will be undertaken. It is proposed to establish new Institutes for fertiliser technology, forage and grasslands research, research on soils and plant virology. Research on fruits, spices, cashewnut and cocoa will be expanded. Regional stations for research on tuber crops other than potato will be set up. A national hortorium will be established to serve as repository of all introduced plants in India. Facilities for research, improvement and testing of agricultural implements will also be developed on a considerable scale.

44. All the Divisions of the Indian Agricultural Research Institute will be expanded during the Third Plan. Several superior hybrids and synthetic varieties in maize and the major millets are to be developed. Mutation inducing methods using radioisotopes and chemical mutagens will be further exploited for crop improvement. Facilities of the artificial climate house (phy-totron) will be developed and utilised for studies in plant physiology and plant improvement. Research on soil physics will be intensified. A section on plant nematology is to be started for research on nematodes causing damage to agricultural crops. Work on insect pests with reference to their genetics and resistance of plants to insects will be expanded. Other additions will be a tillage laboratory and a hydraulics and general engineering laboratory.

45. Research on various commodities under the various Commodity Committees will generally aim at increasing yield and improving quality. Breeding work on different crops for obtaining high yielding varieties resistant to diseases will be developed further. Technological research on cotton, jute, tobacco, etc. will aim at improvement in the methods of processing, packing and manufacture. In the case of jute and lac, the effort will be to evolve new uses. Emphasis will also be laid on the utilisation of by-products such as coconut husks, jute sticks, coir, tobacco wastes, lac waste, cotton wastes, cotton seed hulls, etc.

46. Work relating to agro-economic research initiated during the first two Plans at the Agro-Economic Research Centres started by the Ministry of Food and Agriculture will be further intensified. It is also proposed to extend farm management studies to cover selected regions in all States.

47. Soil conservation.—The main soil conservation problems in India have been classified region-wise and a number of research programmes have been initiated. In addition to the existing Research-cum-Demonstration and Training Centres, two more research centres for rpd soil areas will be established during the Third Plan one in Orissa representing high rainfall areas, and the other in Andhra Pradesh representing low rainfall areas.

Research programmes in soil conservation will include both applied and fundamental studies. Among the former may be mentioned studies of the various aspects of soil, agronomic studies concerned with cultivation and crop rotation, mixed-cropping, strip cropping, trials with green manuring crops, cultivation of horticultural crops in the slopes of hills, agrostological studies on various grasses for erosion control and pasture management, studies of

afforestation, regeneration and water-shed management, engineering studies on different cross sections, grades and lengths of control bunds, and bench terraces, reclamation of gullies by different types of check dams, construction of earth dams and studies of various aspects of desert land and of the economics of soil conservation measures. The fundamental studies will include investigations on basic laws governing hydrological behaviour of water-sheds under various management practices and basic soil investigations in relation to soil and water conservation.

48. Animal husbandry.—Research in animal husbandry has covered various aspects of breeding, feeding and disease control. At a large number of centres, research which has been undertaken under field conditions concerning cross-breeding of non-descript cattle in hilly and high rainfall areas has shown that under these conditions there is improvement in milk-yield in the progeny. A coordinated research scheme on the merits of selective breeding of certain local types of cattle as against their grading up with well defined breeds of greater productive capacity has been initiated. Research on artificial insemination has provided a powerful tool in the hands of breeders in improving the breeds.

Besides research on animal nutrition at Izat-nagar, regional animal nutrition stations have been established. These have facilitated studies in the chemical composition and nutritive value of available foodstuffs in different regions and for detecting and correcting nutritional deficiencies. Research on the improvement of the nutritive value of paddy straw, which forms the bulk of nutrition for cattle in the country, has shown simple methods of treatment which can be resorted to for removing deleterious effects caused by feeding- paddy straw. Work has also been done on the feeding value of certain fodders and tree leaves that can be made use of during scarcity or famine periods.

Investigations on animal diseases have been carried out on an extensive scale. Useful results have been secured regarding the causative factors of certain diseases and their treatment and prevention. Research on rinderpest has led to the development of the freeze-dried goat tissue vaccine which is now being used for immunising comparatively resistant cattle of the plains and development of the lapinised and lapini-sed-avin'sed vaccine for immunising the more susceptible hill cattle. A vaccine was also evolved for immunisation against pasteurellosis.

49. In the Third Plan, the Indian Council of Agricultural Research will continue many of the current schemes of research on different aspects of animal husbandry. Pilot investigations on cross-breeding of indigenous cattle in areas of heavy rainfall and high altitude will be continued. Work will also continue on determining the relative value of selective breeding, grading up and cross-breeding in different regions of the country. Further studies on nutritional requirements of Indian cattle and buffaloes will be undertaken. Investigations on the control and eradication of humpsores disease of cattle will be undertaken on a coordinated basis. Investigations on control of brucellosis in cattle and various diseases of sheep and goats, pigs and poultry will also be carried out. Breeding studies on pigs and other animals will also be extended. Studies on physiological norms of various species and breeds of livestock, on production of fodders and carrying capacity of pasture and forage crops will be undertaken. New schemes are also to be undertaken on investigations of mucosal disease and salmonella infection in farm animals and yellow disease of cattle. Investigation will also be undertaken on control of tuberculosis. It is proposed to start livestock research stations in the States for intensifying research on local and regional problems. Regional animal nutrition research stations will be placed on a permanent footing.

50. Selective breeding of sheep and cross-breeding with exotic breeds like Rambouillet has been carried out with a view to evolving suitable breeds for the production of fine apparel wool. In the Third Plan research will be undertaken on sheep production in mixed farming economy. Studies on artificial insemination will be extended in sheep. The Indian Council of Agricultural Research proposes to establish a Central Sheep and Wool Research Station.

51. In the field of poultry development, economic, balanced poultry rations have been evolved. An indigenous strain of birds has been developed with high egg production. Methods were developed for defertilising eggs with a view to increasing their keeping quality. Cheap hatcheries were established successfully and the use of such hatcheries in forming poultry development blocks was demonstrated. Successful experiments were carried out in which broilers were produced having a body weight of 3¹ pounds in 10 weeks. In the Third Plan, work on hybridisation of inbred lines of selected poultry breeds and progeny testing of poultry will be extended. Investigation on problems of housing poultry in cheap poultry houses constructed with material available in rural areas will continue. Coordinated schemes on economic poultry ration will be continued to investigate cheaper feeds including agricultural by-products and industrial wastes.

52. Dairying.—Research work has been undertaken on economical methods of manufacture of milk products and by-products under village conditions. Research on the bacteriological and chemical quality of milk in different regions has yielded information which has helped in designing several important dairy development schemes. Improved methods for making ghes have been evolved and a new method of detecting adulteration in milk has been established.

New studies on evolving new breeds of dairy cattle by cross-breeding indigenous cows with Jersey bulls and grading up Kangayam breed of cattle with Tharparkar will be undertaken. Research on the comparative economics of

specialised dairy farming versus arable farming versus mixed farming will be further intensified. Studies designed to reduce the cost of maturity of calves by feeding with milk substitutes will be undertaken. Problems of storage and transport of large quantities of milk and processing of high acid cream for making butter, etc. will be investigated. Investigations are also contemplated on mineral metabolism in ruminants with the aid of radioactive isotopes.

National Dairy Research Institute will initiate research on nutritional physiology of different breeds of cattle, pasture management, growth rate of calves, studies on problems relating to technological aspects of bulk: milk processing, handling and distribution, as also studies on manufacture, packaging and storage of milk products. Research on dairy utensils, bacteriology of milk and milk products, residual antibiotics, regional compositions of milk, detection of adulteration, keeping quality and mineral balance of milk will be taken up. A new Division on dietetics will be set up for research on nutritive aspects of milk and milk products.

53. Forest research.—Many of the research schemes sanctioned at the Forest Research Institute, Dehra Dun, during the Second Plan will continue during the Third Plan. These include studies on plant genetics of forest trees, forest influences, epidemiology of forest insects and pests, protection of timber against marine borers, preservation of green bamboos, introduction of Malayan cane in India, coordination of silvicultural research in the States, volume and yield table for Indian timbers and others. In addition, new research schemes will also be taken up during the Third Plan, such as studies on forest soils, ecology of forest life, grazing and fodder research, and research on the utilisation of the barks of Indian trees. It is also proposed to establish several regional research centres, a biological wing at Jabalpur and a utilisation wing at Nagpur. The research centres at Ban-galore and Coimbatore will be strengthened.

54. Fisheries.—At the Central Marine Fisheries Research Station, Mandapam, research schemes on the productivity of Indian seas, oceanographic studies in relation to fisheries, molluscan fisheries, fish food availability, etc will be continued. New schemes to be taken up will include specific studies on mackerels, sardines, prawns, etc.

The Central Inland Fisheries Station, Bar-rackpore, will continue current investigations concerning pond culture, riverine, lacustrine and estuarine fisheries. The new projects to be initiated will include survey of the Brahmaputra, investigations on high altitude, fresh water and backwater fisheries, fish behaviour in relation to dams, etc.

The Central Deep Sea Fishing Station, Bombay, was established for charting marine fishing grounds, determining fishing seasons and fishing intensities, assessing the suitability of fishing implements, training of personnel, etc. During the Third Plan, besides expanding the exploratory and experimental fishing programmes at Bombay, Tuticorin, Cochin and Visakhapatnam, additional units will be established at Manga-lore, Kakinada, Paradwip and Port Blair.

The Central Fisheries Technological Research Station, Cochin, undertakes research on the design of fishing craft and gear, craft and gear materials and their preservation, methods of fishing and preservation of fish, commodity standards, and marketing and inspection. Larger programmes for investigating improved designs of mechanised fishing craft for different regions, beach boats, gear materials and their preservation, etc. will be undertaken during the Third Plan.

VI.MEDICAL RESEARCH

55. Medical research is promoted and coordinated by the Indian Council of Medical Research. Programmes for the Third Plan have been drawn up against the background of work initiated during recent years. It is proposed to intensify research on communicable diseases like tuberculosis, cholera, leprosy, infantile diarrhoea, filariasis, etc. and to set up permanent research centres for tuberculosis and cholera.

A full-fledged centre for doing research on arthropod-borne viruses has already been established at Poona, and facilities for virus research at the Pasteur Institute, Coonoor, have been strengthened. The Indian Council of Medical Research has also encouraged research in virus diseases at selected medical colleges. Facilities have been provided at the Virus Research Centre, Poona, for training medical scientists in the techniques of virology. Work in the field of virus diseases will be expanded during the Third Five Year Plan, and a trachoma research centre will be established at Aligarh in association with the university.

The Indian Council of Medical Research has been supporting work in the field of cardiovascular diseases, metabolic disorders, intestinal parasitism and venereal and other diseases. Besides continuing work in these fields, during the Third Plan, attention will be focussed on problems of metabolism concerning proteins and carbohydrates. Investigations will also be sponsored on intestinal infestation with entamoeba, and various helminthic parasites. Research on mental diseases will be continued at the All-India Institute of Mental Health, Bangalore. Research on problems of maternity, child welfare, nutrition and related problems will also be expanded. Research facilities in medical colleges will be strengthened. Research in occupational health will be taken up at two or three new centres in addition to work at the All-India Institute of Hygiene and Public Health.

56. During the Second Plan, the Indian Council of Medical Research sanctioned the establishment of a number of research units to investigate indigenous drugs. So far seven such units have been established. During the Third Plan, additional drugs will be taken up for study.

57. Demographic, medical and biological research in family planning has been carried out during the Second Plan. A large number of mechanical and chemical contraceptives have been tested. Research on oral contraceptives including meta-xylo-hydroquinone and indigenous medicines, is being undertaken. The Human Variation Unit at Bombay is carrying out work on the distribution of genes in certain areas. A long term study on twins and consanguinity begun in 1954 has also been carried out. These investigations will be continued and expanded during the Third Plan.

VII. OTHER PROGRAMMES OF RESEARCH

58. Irrigation and power.—There are at present 19 hydraulic and irrigation research stations in the country. Two of them (Poona and Delhi) are maintained by the Central Government; the others are with the States. The Central Board of Irrigation and Power coordinates research in irrigation and power. In 1953, it formulated a comprehensive programme of fundamental and applied research on irrigation and assigned projects to different research stations. Among the problems taken up for investigation were air-entrainment, turbulence, cavitation, design of channels, properties of soils, sedimentation in relation to reservoir performance, underground waters, use of surkhi as a puzzolona and economic alternatives to stone in the construction of structures. These investigations will be continued during the Third Plan. New research problems to be taken up in the Third Plan include utilisation of isotopes in subsoil water studies, compaction of different soils, development of pre-cast techniques for hydraulic structures, evolving silt disposal techniques, and measures for minimising losses due to absorption, percolation and evaporation.

59. It is proposed to expand the scope and functions of the present Power Research Institute at Bangalore and to establish a Switchgear Testing and Development Laboratory at Bhopal on a site adjacent to the Heavy Electrical Plant. The Power Research Institute at Bangalore will have four fully equipped Divisions dealing with high voltage general electrical engineering, mechanical engineering, and hydraulic engineering as well as ancillary facilities for conducting pilot plant and miniature field studies. The Institute will provide scope for development work on electrical insulating materials available in the country such as wood, mica, paper, etc., development of potential and current transformers and other equipment and the study of lightning phenomena and vibration and mechanical problems of transmission lines.

60. Transport and construction.—The headquarters of the Railway Research, Design and Standards Organisation is at Simla, and its Research Directorate with testing and research equipment and a yard served both by broad gauge and metre gauge is at Lucknow. The Metallurgical and Chemical Section of the Research Directorate is situated at Chittaranjan and facilities for carrying out tests and trials for this Section have been established there. The main fields of research for the railways are interplay between track and wheels in motion, testing of prototypes involving trials of vehicles in motion and in rest, performance trials covering full assemblies like locomotives, rolling stock, track and bridges, components of these items, fuels, lubricants and preservatives, progressive replacement of imported items of railway stores by indigenous products, utilisation of waste products such as coal ash, saw-dust and spent lubricants, and soil mechanics as applied to stability of banks, cuttings and foundations of structures.

61. The Ministry of Transport through its Roads Wing coordinates, assists and sponsors research relating to roads. Some of the problems in the field of roads to which attention has been devoted during the past few years, specially at the Central Road Research Institute, include methods of soil stabilisation using locally available materials or evolving cheap all-weather roads, stabilisation of black cotton soils for road construction, study of bearing value of soils, evaluation of stone and brick aggregate for road construction, bituminous stabilisation of fine sands, use of local kankar for roads in desert areas, specifications for bituminous roads in areas of very heavy rainfall, methods for quick repair of culverts and minor bridges, design and thickness of various types of pavements, load transmission properties of various materials used in road construction, road construction methods in marshy areas, investigations on road users' behaviour, geometric design of roads and crossings suitable for mixed, slow and fast traffic, traffic problems for achieving safety on the roads, and improvement in the design of bullock-cart wheel axle system. During the Third Plan, the Roads Wing proposes to undertake experimental construction of low cost stabilised soil roads for light traffic. The research programme of Central Road Research Institute is divided under five broad categories, namely, soils, bitumen, concrete, road design and traffic engineering. During the Third Plan period, the Institute also proposes to take up research on bridges.

62. During the Third Plan, the activities of the National Buildings Organisation will mainly centre round reduction in building costs through the introduction of new and cheaper materials, new building techniques and better methods of construction. The National Buildings Organisation will, sponsor research and investigations on traditional and new building materials, more economic and efficient designs for buildings both in urban and in rural areas, bearing capacity of soils, suitability of soils, for brick-making, suitable designs of foundations on shrinkable soils, strength of

masonry, corrosion of steel and damp-proofing. Norms and standards are to be laid down for various types of buildings. Developments in techniques of construction such as prestressed concrete, shell construction, prefabricated construction, etc. will be promoted. Studies on productivity in different operations in the building industry will also be undertaken.

63. Minerals.—The principal organisations engaged in research and surveys for minerals are the Geological Survey of India, the Indian Bureau of Mines and the Oil and Natural Gas Commission.

The research activities of Geological Survey of India during the Third Plan period will comprise fundamental petrological, chemical and palaeontological investigations and applied studies relating to geological mapping, preliminary mineral assessment, investigation concerning coal, base metals and other minerals and metals, engineering geology, groundwater assessment and geophysical problems. Geophysical methods of exploration are being made use of by the Survey in the investigation of various types of mineral deposits, metallic as well as non-metallic.

Intensive geological studies for non-ferrous metals are to be undertaken by the Indian Bureau of Mines in different parts of the country. Studies on other minerals such as iron, coal, asbestos, bauxite, gold, diamond, etc. are also envisaged. Mining research will be intensified. Pilot plant investigations on the beneficiation of copper ore, copper-lead-zinc ores and manganese ore will be carried out. The utilisation of iron ore fines by sintering will have an important place in the Bureau's research programme. Suitable processes for the treatment of chromite, ilmenite sands, pyrites, gypsum, magnesite, limestone, diamonds, graphite, fluorspar and clays will be evolved. Analytical methods will be developed with new reagents for ores and minerals with a view to saving time and cost. Investigations into application of solvent extraction techniques in the chemical estimation of minerals and ores will also be carried out. Work on the utilisation of indigenous manganese dioxide for the manufacture of batteries, use of silica in abrasives and the problems of ferro-manganese industry will be expanded.

The research work of the Oil and Natural Gas Commission is undertaken through the technical Divisions for geology, geophysics, and engineering. The Geology Division is concerned with photogeomorphological studies in respect of some 250,000 square miles of territory for delineating subsurface structural trends. The Division also proposes to undertake studies on drilling muds, oil well cements, properties of core samples, testing and treatment of crude oils, petroleum source rock studies and flow properties of natural gas through porous media.

64. Communications.—Research on communications includes meteorology, broadcasting, wireless and telecommunications and civil aviation.

In the Third Plan, the workshop and laboratories of the Meteorological Department are proposed to be expanded and improved with a view to attaining self-sufficiency in respect of instruments required for use in meteorological observations. Electronic instruments for measurement of cloud height and thickness, wind determination, and storm-detecting radar will be designed and developed. It is also proposed to bring out a treatise on the Meteorology of India and an Agro-Climatological Atlas of India. The network of Rawinsonde-Radiosonde Stations will be strengthened by starting 18 additional stations with modern equipment. Additional seismological observatories will be established and seismographs will be made in the workshops of the Department. Work on atmospheric electricity and atmospheric pollution measurement will be started at a few stations. The Colaba Observatory will take up ionospheric studies and study of night sky and air glow. Facilities for astro-physical and astronomical studies will be expanded at the Kodaikanal Observatory, and at a Central Astronomical Observatory to be started near Ujjain and at a Naval Astronomical Observatory. It is also proposed to set up a Northern Hemispheric Collection and Analysis Centre at New Delhi to collect, study and disseminate meteorological data and analyses for the whole northern hemisphere. This project is important for aviation weather forecasting and specially for forecasting for long distance aviation.

65. The programme of work to be carried out during the Third Plan period by the Research Department of the All India Radio will include intensification of studies in the fields of very high and ultra high frequencies and microwave techniques and propagation, semi-conductor and transistor technology and their application to designs of equipment for broadcasting, and television transmission and reception. It is proposed to augment and improve equipment and facilities for collecting ionospheric data for investigation on atmospheric noise and ionospheric absorption and for studies on scatter propagation. To facilitate exchange of recorded material between the All India Radio and other broadcasting organisations, standardisation of tape-recording techniques and equipment will be undertaken. Standardisation and development of audio equipments required for broadcasting and stereo techniques for stereo transmission and reception will be undertaken. Another important project will be the development of suitable indigenous sound absorption and insulation material for use in studios.

66. The programme of work of the Wireless Planning and Coordination Branch of the Ministry of Transport and Communications includes amongst others :—

- i. systematic study of atmospheric noise in the band of 50 kilocycles to 30 megacycles;

- ii. systematic study of ionospheric conditions existing at different localities in India;
- iii. systematic measurements for the evaluation of the degree of interference produced by man-made noises in urban areas; and
- iv. determination of signal to noise ratios required for different percentages of reliability of working of various types of telecommunication circuits.

The main activity of the Telecommunications Research Centre, which functions under the Directorate General of Posts and Telegraphs, is to undertake investigations and development work in order to improve the telephone and telegraph services to the public and to provide designs of telecommunication equipment to the Indian Telephone Industries and other manufacturing units in the country.

67. Principal projects to be carried out by the Research and Development Directorate of the Civil Aviation Department during the Third Plan period are : (i) full-scale structural tests on airframes and wings, (ii) type testing of piston and turbine power plants including propellers, (iii) development and standardisation of indigenous aircraft materials, equipment and processes, (iv) development of safety devices, (v) design and development of gliders and light aircraft for personal agricultural and other uses, and (vi) study of fatigue of aircraft structures and other problems of primary importance to civil aviation.

VIII. SUGAR, JUTE AND OTHER INDUSTRIES

68. Research for the metallurgical, engineering, chemical, food and mining industries is being undertaken in the national laboratories and in various departments and research institutions. Besides these, reference should be made to the research programmes relating to sugar, jute, cotton, and silk and art silk industries, and to cottage and small scale industries.

Research on sugar is undertaken at the National Sugar Institute, Kanpur. The Institute has a programme for the Third Plan period which includes (the provision of laboratory equipment for advanced research, an experimental factory and fabrication of pilot plants. Among problems to be studied are combustion control, research on high polymers and on candy and confectionary industries, and utilisation of byproducts.

The Technological Research Laboratories of the Indian Central Jute Committee has a programme of research on composition and chemical modification of jute hemicelluloses so as to render them more resistant to swelling in water and attack by micro-organisms, effects of heat and moisture on fibres, orientation and cell dimension of jute fibres at different stages of growth, study of bacteria and fungi which rot jute plants, utilisation of jute sticks for pulp and paper, possible new uses of jute including furnishing fabrics, improvement of wet strength of bleached jute yarn, prevention of seepage of cement from jute bags, manufacture of non-woven fabrics for book-binding cloth, rexin and other purposes, and improvements in the processing of mesta and other substitute fibres. The Research Institute of the Indian Jute Mills Association is engaged in the study of mechanical and other properties and chemical composition of jute and bast fibres, effects of fungi, bacteria and environmental factors on deterioration of jute and the development of proofing and finishing operations for jute fabrics.

The Technological Laboratory of the Indian Central Cotton Committee undertakes spinning tests, measurement of fibre properties and determination of spinning value with a view to help the breeders. The Ahmedabad Textile Industries Research Association (ATIRA) has a programme of studies for the Third Plan which includes relationship between molecular structure and properties of cellulose, nature of polymer formation when thermosetting resins are applied to cotton fibres, effects of addition of softeners and inorganic salts on properties of polymers like starch, used in making size mixtures, improvement of thermal drying processes, effect of drying processes on finish, technology of washing, design and development of scientific instruments required by the textile industry, effect of arrangements of fibres in yarn on yarn quality, and mechanism of absorption of different substances by textile fibres.

The Silk and Art Silk Mills Research Association came into being in 1958-59. Its pilot mill, laboratories and technical institute are nearing completion. The Association proposes to investigate problems presented by its members in respect of fibres, yarns and fabrics, to locate defects in manufacturing processes and suggest methods for removing them and to assess the suitability of rayon fabrics for export. Improvement of fibre production, yarn processing, fabric manufacture and finishing will also be undertaken.

69. Cottage and small scale industries.—A Central Research Institute for Village Industries under the All-India Khadi and Village Industries Board is functioning at Wardha. The Institute has laboratories for control and development of processes and products, workshops for designing and developing improved tools and implements, and experimental production centres for the study of tools and techniques. Besides this Institute, a number of other research centres have also been established.

The Coir Board maintains the Central Coir Research Institute in Kerala and a branch institute in West Bengal. The

Board proposes to undertake research on both fundamental and applied aspects of coir fibre and yarn. Fundamental schemes will be directed towards the elucidation of the physical, chemical, biological and other basic properties of coir fibre and yarn. Comparative study of competing fibres such as sisal and aloe will also be undertaken. Applied research schemes will centre round methods of extracting coir fibre so as to reduce retting time and labour, an improved pedal-operated spinning machine, rope-making machines, three matting looms pilot plant, utilisation of coconut pith and coir waste, dyeing of coir fibre and yarn and development of new and non-conventional uses for coir and coir products.

There are three research institutes for sericulture one each in West Bengal, Mysore and Assam. The Central Silk Board proposes to set up two regional research stations in Bihar and Jammu and Kashmir and a sub-station at Kalimpong. The main problems of the silk industry concern improvement in quality and reduction in costs. At the research stations efforts will be made to evolve new and improved silkworm races.

The Handloom Board has drawn up plans to re-organise the two existing institutes for hand-loom technology. The Board has in view a number of research schemes, such as design of suitable small sizing and beaming equipment, use of non-mulberry silk fabrics, cottage-scale dyeing and processing of synthetic fibres, anti-crease and other finishes for handloom fabrics, design of a portable reeling machine for tussore, use of vegetable colours in combination with synthetic ones, and mechanical preparation of bamboo reeds.

In the field of small scale industries, it is proposed to consolidate and enlarge the activities of the Small Industries Service Institutes and the Extension Centres including those pertaining to research on problems like proper use of raw materials, improved technical processes and design of machinery.

IX. RESEARCH IN UNIVERSITIES AND INSTITUTES OF HIGHER TECHNOLOGY

70. Fundamental research in all branches of science has to be undertaken mainly in the universities. They are also the source of all the technical and scientific manpower required for the development of industry. In the context of the rapid advance of science and technology, the role of the universities has become extraordinarily important. Support for basic research in the universities is essential for ensuring the quality of applied research in every field. Organisations like Council of Scientific and Industrial Research, Indian Council of Agricultural Research and Indian Council of Medical Research sponsor research projects at the universities, but, in the nature of things, their emphasis has to be largely on applied research. The University Grants Commission has endeavoured to assist the expansion of facilities for basic research in the universities.

71. There are at present 46 universities besides the institutes of technology. A majority of them have facilities for advanced research in several branches of science. During the Second Plan, a number of centres of specialised research were established in the universities with assistance from the University Grants Commission, as for example, experimental astronomy at Hyderabad, theoretical astronomy at Delhi, cosmic ray research at Aligarh, and Jammu and Kashmir, biological oceanography at Annamalai, and Trivandrum, X-ray and crystallography in Calcutta, Andhra, Delhi and Aligarh, spectroscopy at Banaras and Kamatak, electronics and applied physics at Calcutta and Allahabad, animal genetics at Chandigarh and plant physiology at Banaras, Delhi and Calcutta. The Council of Scientific and Industrial Research has sponsored a School of Earthquake Engineering Research at the University of Roorkee. In the Third Plan period, the existing research departments will be consolidated and strengthened and research facilities will be developed in such fields as applied geology, geophysics, radio-astronomy, oceanography and basic medical sciences.

72. Engineering research.—Although the University of Roorkee had done pioneering work in hydraulics research during the nineties of the last century, engineering research in the country had made little more than a beginning by the close of the First Five Year Plan. With the advent of large scale development in industry under the Five Year Plans, new opportunities came to India's engineers to undertake original and creative research and to assume responsibility for all major designs, fabrication and construction. However, even at present, only a few of the engineering colleges have facilities for research, although these are now being developed in the higher technological and post-graduate institutions, such as the Indian Institute of Science, Roorkee University, Jadavpur University, Madras Institute of Technology and the Institutes of Technology at Kharagpur, Bombay, Madras and Kanpur. During the Second Five Year Plan, hydraulics research was revived at the Roorkee University and additional research problems in earthquake engineering and structural dynamics were taken up. The Indian Institute of Science, Bangalore, was engaged in research in power engineering, metallurgy, internal combustion engines, gas turbines and aeronautical engineering. The Indian Institute of Technology, Kharagpur, was carrying out research in electron tube oscillators and amplifiers, transistors and microwaves, naval architecture and ship model tank experiments.

73. Facilities at the various national laboratories are also being increasingly used for carrying out schemes of engineering research such as wind power, water purification, solar power, etc. as well as for various mechanical, electrical and telecommunication projects. Among the national laboratories engaged in engineering research are the Central Road Research Institute, the Central Building Research Institute, the National Metallurgical Laboratory, the

Central Fuel Research Institute, the Central Electronics Engineering Research Institute, the Central Public Health Engineering Research Institute, the Central Mechanical Engineering Research Institute and the Central Mining Research Station.

Considerable engineering research work is also being carried out at the Atomic' Energy Establishment, Trombay. It is directed mainly towards solving engineering problems connected with the design and construction of atomic reactors for research and for the production of economic nuclear power. Work is also proceeding on the testing of materials and complete reactor systems under actual irradiation conditions. Research work in connection with the production of electronic instruments and of silicon and germanium for the manufacture of transistors is also in hand.

Larger resources are being provided in the Third Plan for the promotion of engineering research. A special committee is at present engaged in studying programmes relating to postgraduate education and research in engineering.

74. Research in statistics.—Facilities for statistical investigations and research have been considerably expanded during the first two Plans. The National Sample Survey is the principal agency for undertaking sample surveys for the collection of statistical data. The State Statistical Bureaus collaborate with the National Sample Survey over a wide range of sampling enquiries. Fundamental research in the theory of statistics and development of new statistical tools for applications in different fields is undertaken by the Indian Statistical Institute which is also responsible for the design of enquiries undertaken by the National Sample Survey and for tabulation of data collected by it. Technical studies relating to planning are carried out by the Economic Wing, the Operational Research Unit and the Regional Survey Unit of the Indian Statistical Institute. The Central Statistical Organization and the State Statistical Bureaus work in close collaboration with one another. The Central Government has recently established the Department of Statistics for advising Ministries and States on statistical matters and providing general directions regarding the setting up of standards and norms and methods of collection of statistics. In the field of agricultural statistics, research is undertaken by the Institute of Agricultural Statistics.

X. UTILISATION OF SCIENTIFIC RESEARCH

75. The importance of ensuring speedy and extensive utilisation on a commercial scale of the results of scientific research has been stressed for several years. The National Research Development Corporation was set up with the object of exploiting the results of laboratory research for commercial production. Since its inception seven years ago, the Corporation has negotiated about 120 licences for items based on research undertaken within the country, of which more than 30 are in commercial production. The Corporation has also instituted 16 developmental projects. However, a large proportion of the inventions made in the country still remain to be exploited. Intervals between the time when the results of laboratory research become available and their wider application, are at present considerable and there is need for more effective action. It has been suggested that the rapid utilisation of the results of research is hindered on account of such factors as lack of pilot plant facilities and of design and fabrication facilities, inadequate liaison between industry and research organisations, insufficient attention on the part of industry to the urgent need to secure indigenous production to replace imported articles, and inadequate coordination between licencing policies and programmes for the development of research. Facilities for design and fabrication of pilot plants are now available in much larger measure than before and such deficiencies as exist will be made up to a considerable extent during the Third Plan. The other aspects to which attention has been drawn above are essentially matters of an organisational approach. It is crucial that there should be close association between research workers and individual industries, fuller knowledge and greater understanding on their part, both of problems requiring solution and of the results obtained, and adoption by such industries of carefully considered schemes for the utilisation of the results of research, replacement of imported items by indigenous manufactures and achievement of higher standards based on research undertaken within the country. In particular. Development Councils and other organisations concerned with different industries should regard such schemes as an essential of their programmes of development during the Third Five Year Plan. They should ensure that research workers receive the necessary assistance and facilities from industrial plants and from executives and engineers in different industries.

76. The same lags in the utilisation of the results of research which appear in industry are also found in other fields of development such as transport, construction and power. Promising results are secured and new designs, techniques and specifications are evolved. For lack of extended application, due possibly to conservatism or inertia, full value is not realised from expenditures incurred on research, thereby slowing down the process of technical advance and modernisation. In the field of road development, research laboratories of the Central and State Governments have been engaged in evolving improved methods of construction and specifications to ensure their rapid application. It has been suggested that States should devote one per cent of their plan allocations for roads to experimental techniques and construction of suitable stretches of roads provided for in the Third Plan. To cover the possible risk and to meet the additional expenditure that may be involved, a special provision has been made in the roads programme at the Centre. It is proposed that a committee of the Indian Roads Congress should select new techniques of road construction for extended trials. This approach is capable of extended application in other fields of construction and in public utilities.

77. Inventions and patents.—The technological progress of a country is marked by large numbers of inventions, some of major significance and based on prolonged research in the laboratories, others in the nature of improvisations and solutions discovered in the course of every day work by skilled workers and technicians. For the process of industrialisation to strike roots of its own, it is essential that in all fields an effort should be made to stimulate the creative faculties of scientists, technicians and others. In 1959, the Central Government set up the Inventions Promotion Board with the object of encouraging and inculcating the spirit of invention amongst independent workers, artisans and technicians and providing technical and financial assistance. It is to be hoped that State undertakings as well as enterprises in the private sector and various agencies of the Central and State Governments will formulate their own schemes for encouraging inventions on the part of their workers and technicians and give them the necessary support in working out and developing their ideas.

Patents are intended to provide a legal framework favourable to inventions and to their speedy adoption in industry. However, for a considerable period dissatisfaction has been expressed regarding the working of the law relating to patents. A very large proportion of Indian patents are held by foreigners, and of these only a few are being actually worked in the country. A comprehensive review of the legislation and of the administrative and other arrangements relating to patents has recently been undertaken, and proposals on the subject are under the consideration of the Central Government.

XI. SCIENTIFIC INSTRUMENTS

78. Dependence on other countries for the supply of scientific instruments has been an important obstacle in the development of scientific research and in the extension and improvement of facilities for the teaching of science in schools and colleges. The Scientific Instruments Committee (1959) assessed the demand for scientific instruments in different fields and recommended the establishment of a Scientific Instruments Directorate in the Ministry of Commerce and Industry and of a Central Scientific Instruments Organisation under the Council of Scientific and Industrial Research. In pursuance of these recommendations, the Council of Scientific and Industrial Research constituted a Central Scientific Instruments Organisation in October, 1959. The Organisation has undertaken surveys relating to technical problems in the manufacture of scientific instruments, availability of raw materials, expansion of productive capacity, quality control, etc. In recent years, there has been some progress in the production of scientific instruments. There are at present 35 large and medium units engaged in manufacturing scientific, drawing, surveying, mathematical and industrial instruments. Their total production has increased in value from Rs. 63 lakhs in 1956 to Rs. 3 crores in 1960. The capacity of the National Instruments Factory, Calcutta has been increased. There is considerable scope for the production of scientific instruments by small units whose total production has also risen in value between 1956 and 1960 from Rs. 35 lakhs to Rs. 90 lakhs. Considering that imports of scientific instruments have been in the range of Rs. 10 crores a year, this is a field in which large increases in production can be speedily achieved. To enable existing and potential manufacturers to arrange for production on a long-term basis, it is essential that Government departments and educational institutions should plan their requirements on a long-term basis and make these known to manufacturers, firm orders being placed to the extent possible. It is observed that under the existing procedures, even apart from the absence of advance planning, sometimes funds are allotted to educational institutions late in the year, resulting perhaps in hasty expenditures and unsatisfactory purchases. The purchase organisations of the Central and State Governments and the various indenting authorities should collaborate in the improvement of the prevailing procedures in relation to the development of the scientific instruments industry.

XII. STANDARDISATION QUALITY CONTROL AND PRODUCTIVITY

79. Metric weights and measures.—The decision to standardise weights and measures throughout the country on the basis of the metric system was taken early in the Second Plan. During the past two years, the metric system has been adopted in several sectors. Industries using the system in their commercial transactions, include cotton and jute textiles, iron and steel, non-ferrous metals, engineering, chemicals, cement, paper, petroleum, etc. Rates of customs and excise duties are now expressed in metric units and the railways, ports, shipping, import and export trade control and a number of other agencies of the Central and State Governments have changed over to the metric system. In certain areas, metric weights were first introduced in October 1958, and have been compulsory since October, 1960. In the rest of the country, metric weights will be compulsory from April, 1962. It is proposed to introduce metric capacity measures in trade in 1961 and metric length measures in 1962. In the course of the next three years, the metric system will have replaced other systems to a substantial extent. After December, 1966, the metric system will be the only system recognised by law.

80. Standardisation.—Standardisation has an important role in industrial development and in the efficient utilisation of resources. Since its establishment in 1947, the Indian Standards Institution has evolved national standards in most fields of industry, including agriculture and food products, and there are at present about 1900 standards in force. Under the Indian Standards Certification Mark Act, 1952, increasing numbers of licences are being issued for certifying goods conforming to Indian Standards'. The Indian Standards Institution works in close cooperation with industry. The objectives of standardisation are promoted through special Standards Conventions and, as a matter of

policy, the Central and State Governments adopt the procedure of indenting supplies on the basis of Indian Standards. During the Second Plan, the rate of preparation of Indian Standards increased by about 70 per cent. In the Third Plan, the rate achieved at the end of the Second Plan is expected to be doubled. Greater emphasis will be laid in the Third Plan on standards of consumer products. With a view to strengthening the implementation, efforts will be made to encourage standardisation at the plant level, to establish and strengthen consumer organisations and, generally, to intensify programmes of public education. To facilitate the introduction of the metric system in different branches of industry and commerce, the Indian Standards Institution is engaged in converting existing standards and evolving others required for controlling the new weights and measures. The Institution's present facilities, including research laboratories and scientific and technical personnel, will be considerably augmented. Besides arranging for the investigation of problems in various laboratories throughout the country, the Institution will study a series of long-range problems in its own research laboratories.

81. Quality control.—While standards define the levels of desirable quality to be maintained in products, their actual achievement depends upon various techniques which fall under the broad description of 'quality control'. Statistical methods of quality control and sampling techniques are among the most important tools for this purpose and, if correctly applied, lead to substantial increase in efficiency in the utilisation of materials, machinery and personnel and in ensuring the desired quality. The Indian Statistical Institute and its branches undertake the training of personnel and advise industries on problems of statistical quality control. Activity in this field has grown in recent years and is expected to expand more rapidly during the Third Plan. Quality control has unlimited possibilities and its effects in improving the quality of products, creating consumer confidence and expanding exports are of great significance for the development of the economy. Quality marking schemes which are being increasingly introduced,—the Indian Standards Institution's certification marking, Agmarking schemes and schemes operated by Export Promotion Councils—represent activities which need to be extended during the Third Plan to many new fields. In particular, pre-shipment inspection and other methods of ensuring the quality of export products should be adopted systematically in all fields, and, if need be, efforts in this direction should be supported by legislation.

82. Productivity.—The rate at which average levels of productivity rise in different sectors is a true measure of the pace and quality of the advance achieved. As has been stated in an earlier Chapter, the only enduring basis for the strength and dynamism of the economy is a rising level of productivity. The productivity movement in the country is yet in its beginnings. However, there is growing realisation of its importance and since the inception of the National Productivity Council in 1958, industry is being increasingly involved in the drive to raise productivity. Over the past three years under the auspices of the National Productivity Council, 43 local productivity councils have come into existence and large numbers of persons have participated in seminars and discussions on productivity and in the effort to make the techniques and problems in this field more widely understood. The National Productivity Council has organised 230 training courses in which about 4000 managers, technicians and supervisors have taken part. Senior executives have also participated in advanced management programmes. In due course, the programmes of the National Productivity Council are expected to be linked up with the work of the proposed All-India Institutes of Management and the National Institute for Training in Industrial Engineering. In the Third Plan, it is proposed to extend the general training programmes for managers, technicians and supervisors to apply productivity techniques in plants on a larger scale and to train instructors in selected productivity techniques. A nation-wide effort to lift levels of productivity involves not only more efficient methods and organisation and a scientific approach, but also changes in human and personal relationships, recognition of the worth of each man, team work and, within each undertaking, a continuing sense of common interest and obligations.

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