SILVER JUBILEE

COMMEMORATION VOLUME

1975

INDIAN INSTITUTE OF TECHNOLOGY

• KHARAGPUR •

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INDIAN INSTITUTE OF TECHNOLOGY

KHARAGPUR

SILVER JUBILEE COMMEMORATION VOLUME • 1975

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From The President of India

राष्ट्रपति भवन नई दिल्ली - 110004
RASHTRAPATI BHAVAN NEW DELHI - 110004
INDIA

June 30, 1975.

On the occasion of the Silver Jubilee Celebrations, I offer my greetings and good wishes to the Staff and the students of the Indian Institute of Technology, Kharagpur. The Institute can look back with satisfaction on its fine record of work. It has indeed made a significant contribution to the scientific and technological development of our country.

I wish the Silver Jubilee Celebrations all success and hope that these will spur the Institute to still greater efforts in the future.

From The Prime Minister of India

Information Adviser

PRIME MINISTER'S SECRETARIAT
NEW DELHI-11

May 28, 1975

Dear Sir,

The Prime Minister is glad to know that the Indian Institute of Technology, Kharagpur, is completing twenty-five years this year. She sends her good wishes for the success of the Institute's Silver Jubilee celebrations.

Yours faithfully,

H. Y. Sharada Prasad

From The Minister of Education & Social Welfare, Government of India

Professor S. Nurul Hasan

MINISTER OF EDUCATION
& SOCIAL WELFARE
GOVERNMENT OF INDIA

New Delhi
25 August 1975

The Indian Institute of Technology, Kharagpur, has played a pioneering role over the last 25 years in developing technical manpower. The Institute has built up a reputation for keeping up with advances in the fast progressing world of technology. While it has played an important role in the past, the responsibility that devolves on the Institute now and for the future is even more. I am certain that the Institute will continue to dedicate itself to fulfilling the national objective of promoting engineering research and teaching.

I send my very good wishes to the Institute on the occasion of its Silver Jubilee.

S. Nurul Hasan

From Chairman, Board of Governors, IIT, Kharagpur

Virginia House
37 Chowringhee
Calcutta 16

I am confident the Silver Jubilee commemoration volume that is shortly being published will be of the usual high standard associated with all publications of this Institute.

With steady industrial development, the last twenty-five years have been years of progress. Many of those who graduated from this Institute of Technology have contributed to our accelerated advancement. Indeed, they have been pacesetters and in the vanguard of our technological growth.

I take this opportunity of wishing your Silver Jubilee Celebrations every success.

A. N. Haksar
Chairman, Board of Governors,
IIT, Kharagpur

Foreword

THE distinction of being the first of the five IITs has not been an unmixed advantage for the Indian Institute of Technology, Kharagpur; it has meant stronger limelight and greater expectations. IIT, Kharagpur, has met this challenge in a manner which has compelled admiration.

I think it a happy turn of my fortune that I joined this Institute with the Silver Jubilee year only a few months ahead. To all those who have built this institution with unflagging devotion and courage I pay my homage. I greet our students, faculty and staff at all levels who are putting in great efforts to make the Silver Jubilee year a memorable one. I gratefully acknowledge the help and guidance given by the Ministry of Education and Social Welfare, Government of India, and our own Board of Governors in the planning of our Silver Jubilee programme.

The present Commemoration Volume is a modest endeavour to project the image of IIT, Kharagpur, as an institute of national importance which has pioneered new thinking on teaching and research in the fields of science, humanities and technology.

C. S. JHA
Director, IIT, Kharagpur

A Short History of the Indian Institute of Technology Kharagpur

THE FIRST twenty-five years in the life of a new-born institution—not a long span in terms of time—has a significance which goes beyond time. The seminal ideas which give birth to an institute, how these ideas are defined and given shape, what the institute sets out to do and what it achieves, the gap between promise and fulfilment—all this can be scanned and measured from the vantage point of the Silver Jubilee year.

To begin with a simple observation which experience has proved true. The history of the Indian Institute of Technology, Kharagpur, epitomizes the new directions of engineering education since 1947 when free India started to shape its own destiny according to its own lights. The IIT, Kharagpur, was born in May 1950 with Dr. J. C. Ghosh (1950–1954) as the first Director. The choice of Dr. Ghosh was a happy augury as he was not only a distinguished savant but a man of vision and fine courage, a man eminently fitted for a challenging task. Dr. Ghosh, assisted by a small secretarial staff, worked in Calcutta before shifting to Hijli. The choice of Hijli as the site of this Institute was also particularly happy as Hijli had many advantages and a special significance too.

While it is not true that the seclusion of a cloister is ideally suited for a teaching and research institute, it is doubtful whether an unplanned metropolis like Calcutta is the right environment for the growth of a university campus. Hijli is not too far away from Calcutta; Kharagpur, a busy railway town, is two miles as the crow flies from here; the big industrial complex at Durgapur is about 100 miles away. Neither pastoral nor pitilessly urban, Hijli can hear the two voices of India. The two-wheeled, mud-plastered bullock carts screech down the macadamized road that runs through the heart of Hijli and the siren at Kharagpur railway workshop hoots at nine o'clock in the morning. This gives Hijli a coign of vantage from which one can see the old, decadent India and the new India that our planners are trying to build. The special significance of Hijli as the site of the Institute was underlined by Jawaharlal Nehru in his first convocation address in 1956. He said: 'My mind

inevitably goes back to that infamous institution—Hijli Detention Camp. Here in the place of that Detention Camp stands this fine monument of India today, representing India's urges, India's future in the making.'

The IIT, Kharagpur, is the first in the chain of five IITs set up in accordance with the recommendations of the Sarkar Committee. The aims and objectives of these institutes of higher technology were firmly outlined in the report of this committee which foresaw the need to reshape the character

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If you indulge in small activities, in small thinking, then you remain small. But if you dare and go in for the really big things of life, then, even in your endeavour to realize them, you become big in the process.

—JAWAHARLAL NEHRU
(First Convocation Address, 1956)

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and content of engineering education in the changed context of the social and economic objectives of large-scale planning. The rapid growth of new technologies and the growing interaction between engineering and basic sciences called for a new pattern of engineering education, and an awareness that any programme of education, technical or general, should concern itself with ends as well as means led to an introduction of wide-ranging courses in humanities and social sciences.

The first session started in August 1951 with 224 freshmen and 42 teachers. Classrooms, labs and administrative offices were housed in the old building which had earlier been the Hijli Detention Camp. One of the walls was still pock-marked with bullet holes—a reminder of an unpleasant past. (A marble plaque was set up in 1960 to commemorate the martyrdom of the two young patriots who fell under police fire on 16 September 1931.) In a memorable speech on the occasion of inaugurating the Institute on 18 August 1951, Maulana Azad urged the older generation not to nurse bitter memories of the past and pleaded with the new generation to realize that they were the beneficiaries of the past.

The Institute started its academic programme with ten departments. Freshmen screened by a rigorous interview—no written test was given—responded quickly to the pioneering spirit which pervaded all levels of life on the campus and a sense of togetherness infected the small community of teachers and students. On 3 March 1952 Jawaharlal Nehru laid the foundation-stone of the New Building. In March 1954 Dr. J. C. Ghosh left the Institute to join the University of Calcutta as its Vice-Chancellor. With his departure

came to an end the formative period in the history of the IIT, Kharagpur.

Dr. S. R. Sen Gupta (1954–1967), who joined in 1954 as the second Director, was in many ways different from his predecessor. Dr. Ghosh was a grand patriarch with an old-world style of administration, laying the foundation of a new institute and giving it sound norms of conduct through precept and practice. Dr. Sen Gupta, who came with an enviable reputation as a tough administrator, set himself the task of tying up loose ends, consolidating and redefining the work of his predecessor. He had a firm grasp of details and a total perspective, and under his stewardship the Institute started to take on a distinctive character.

In the fifties the Institute was greatly helped by two technical aid programmes—UNESCO Technical Assistance Programme and Sisterhood Relationship Scheme with Illinois University. Under these schemes foreign experts came here to assist our research programmes and Indian teachers sent abroad gained valuable experience and expertise. In 1955, for instance, thirteen teachers went to the USA under the Sisterhood Relationship Scheme.

The alpha and the omega, the beginning and the end, we do not know. What we do know is the middle—between the beginning and the end; that is all that you know. Do not therefore attempt to say that all things are understood by you.

—S. RADHAKRISHNAN
(Second Convocation Address, 1957)

Dr. B. C. Roy, the then Chief Minister of West Bengal, was the first Chairman of the Board of Governors and he fostered the new-born Institute with his wise counsel and protective care. Dr. Roy had a great contempt for official trivia; this helped the Institute to grow at a rapid pace. Through his good offices the land on which the campus has since grown—about 1,400 acres—was gifted by the Government of West Bengal to the Central Government.

Dr. S. R. Sen Gupta's term of office was marked by an important event in the history of the Institute. On 15 September 1956 the Indian Parliament passed the Indian Institute of Technology (Kharagpur) Act declaring this institution as one of national importance. This meant an official recognition of the pioneering role of the IIT, Kharagpur, and an affirmation of faith in its future. It also conferred on this Institute, which had earlier been directly administered by the Central government, the status of an autonomous university. Dr. Sen Gupta retired in February 1967, leaving behind a disciplined

and forward-looking institution with the highest standard of academic practices.

Prof. V. N. Prasad (1967–1969), soft-spoken and mild-mannered, took over in February 1967 as the next Director. Working unobtrusively, he handled the problems of growth with sympathy and understanding and strove patiently to preserve the character of this Institute. He left in January 1969, and after a brief stewardship of Prof. S. C. Mitra, Prof. S. K. Bose (1969–1974) joined in June 1969 as the new Director. With his fairly wide experience as the Director of the IIT, Bombay, Prof. Bose brought to bear on his new charge fresh ideas

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Life is one long enchanting school; unfortunate, indeed, are those who go through it like truants.

—ZAKIR HUSAIN
(Seventh Convocation Address, 1962)

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which provoked new thinking. He initiated changes in our curricular programme—the old three-term system was changed to two-semester system—laid the groundwork for new schools of research and set up four centres, viz. Material Science Centre, Rice Process Engineering Centre, Industrial Management Centre and Radar and Communication Centre. The open-air theatre is another fine monument bearing witness to his far-sightedness and enterprise. A big event in the life of this Institute marked Prof. Bose's term of office. The 57th session of the Indian Science Congress was held here in January 1970. It was inaugurated by the Prime Minister of India, Srimati Indira Gandhi. Prof. Bose retired in June 1974.

After a brief stint by Prof. S. C. Mitra, Prof. C. S. Jha (1974—), the present Director, took over in November 1974. Prof. Jha's intelligent and forward-looking leadership promises fresh dimensions of growth for the Indian Institute of Technology, Kharagpur.

Changing Face of the Campus

In the early fifties life on the campus was almost spartan. Most of the teachers, bachelors and grass widowers, shared a few apartments, ate in cheap canteens and slept on steel cots. Amenities were not asked for and one had to walk miles to buy a tube of toothpaste. After sundown street lamps—few and far between—blinked from wooden poles and the roads, mostly unpaved, were not safe to walk on. But life was strangely exciting and we felt like pioneers

roughing it in a virgin land. The campus nestled in *sal* woods. Today life is so different, with all modern amenities one can expect in India—well-lighted streets, clean water at the faucet, well-appointed residential quarters, club houses, shopping centre, children's park, schools, hospital, open-air theatre, composite stadium, swimming pool and, of course, the inevitable suburbs spawning on the periphery of the campus.

Student Life

There are eleven Halls of Residence—ten for boys and one for girls—and the population which is predominantly male has a small but assertive segment of girl students. How the students live and work is an interesting constituent of campus life. Freshmen coming in July do not take long to fall in step with campus life after going through a brief initiation ceremony. Speaking a language rich in local jargons and private innuendoes, our students have grown their own mores of life. Their life is an even balance between work and play. On weekdays they work seven hours in classrooms, labs and workshops—enough to kill a lazybones—and their evenings are spent in sportsfields, gymnasium, cafetaria, wayside cheap canteens or the library. Sports and cultural activities are organized by the Technology Students' Gymkhana which is an almost autonomous student body with a number of specialized societies, like the Technology Dramatic Society, Film Society, etc. The Gymkhana brings out

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I am myself a student of the humanities and I am behind none in recognizing the values which the study of the humanities can inculcate. They have added sweetness and grace to life and they will always be needed to give all men—including technocrats and scientists—a deeper understanding of the nature of man.

—HUMAYUN KABIR
(Eighth Convocation Address, 1963)

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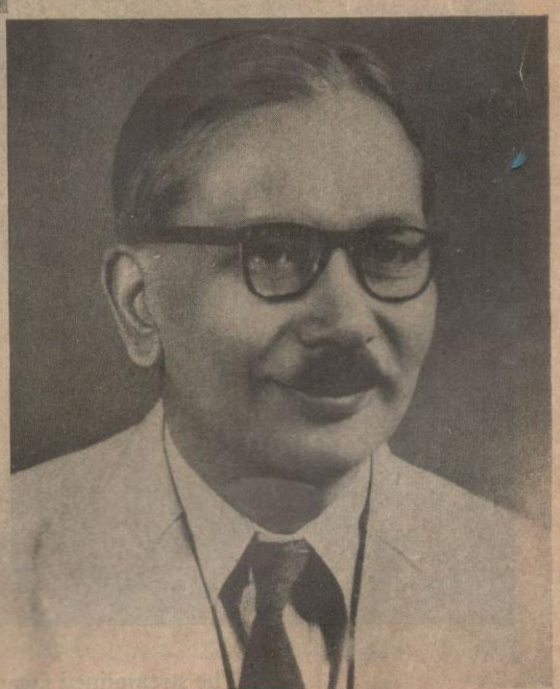
a journal where views are expressed with a candour which embarrasses the elders. The biggest cultural event of the campus is the Annual Spring Festival —a ten-day programme of debates, extempore speech contest, quiz contest, music and drama, with different universities participating. Though apolitical in their reactions to contemporary social and economic problems, their minds are quick and perceptive and in spite of their preoccupation with professional studies which are fairly exacting, they aim, however imperfectly, to live a complete life.

The work and progress of this Institute since 1951 have been twice reviewed. The first Reviewing Committee met under the chairmanship of Sir Willis Jackson in January 1959 and the second under the chairmanship of Sri G. Pande visited the Institute in 1970. Starting with ten departments the Institute has at present sixteen departments and four centres. Research, postgraduate teaching and consultancy work have been some of the most notable areas of growth. The educational policy of the Institute underlined research as one of its major objectives and the achievement of the IIT, Kharagpur, in the field of research has not been inconspicuous. A short résumé of research work done over the past twenty-five years has been appended to this survey. Expansion of the postgraduate programme has been equally impressive. To cite two instances. In 1952 the Department of Civil Engineering offered one postgraduate course and in 1974 the number of courses increased to five. The Department of Mechanical Engineering started its postgraduate programme in 1951 with two courses and in 1973 the number increased to six. The growth of the Computer Centre is another indicator of the growth of this Institute. The Computer Centre has developed around two Analogue Computers and one small Digital Computer (IBM–1620). One of the Analogue Computers was built here and the other purchased and installed in 1960. The Digital Computer was installed in 1964. Rapid expansion in our training and research programmes and the growing demand of sister institutions, research laboratories and industrial organizations on our Computer Centre called for a faster computer system and the Institute has now been able to procure one high-speed Russian Digital Computer EC–1030 consisting of a central processing unit, magnetic tape and disc units, control unit, paper and card punch, printer and other accessories. The Computer Centre plans to offer short-term courses in various aspects of Computer Science.

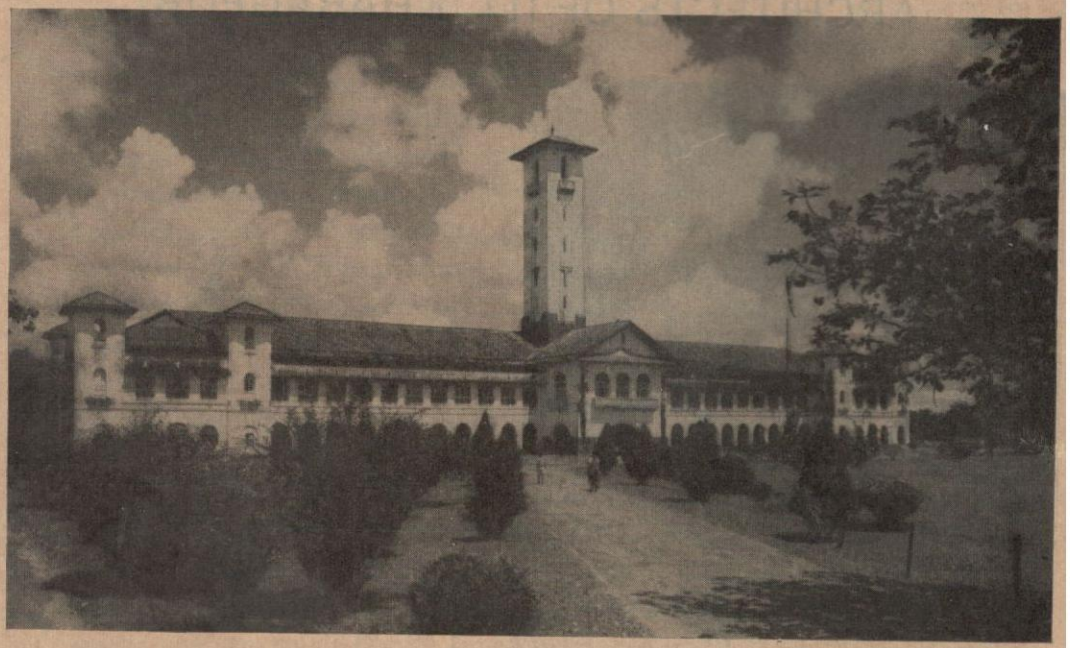
The growth of infrastructure—new buildings housing different departments, labs, workshops, equipment—has been spectacular but perhaps more important than this has been the growth of a distinctive personality, an intelligent aristocracy which one misses in the older universities.

ARCHITECTS OF IIT, KHARAGPUR

Dr B. C. Roy, the first Chairman
of our Board of Governors



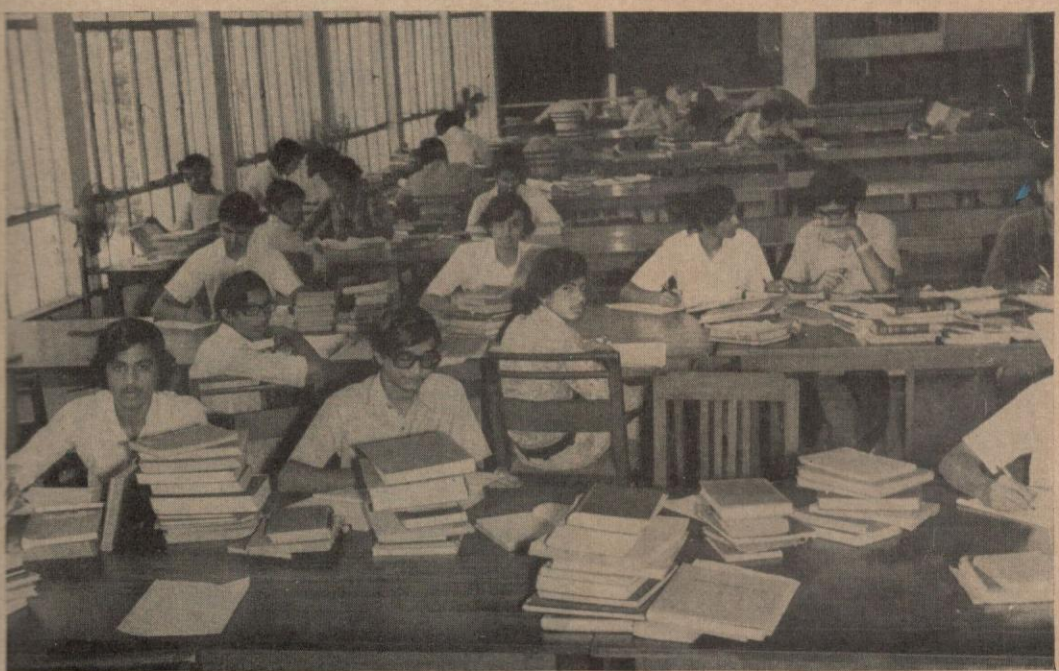
Dr J. C. Ghosh,
our first Director



A view of the Old Building: Hijli Detention Camp transfigured into a temple of learning

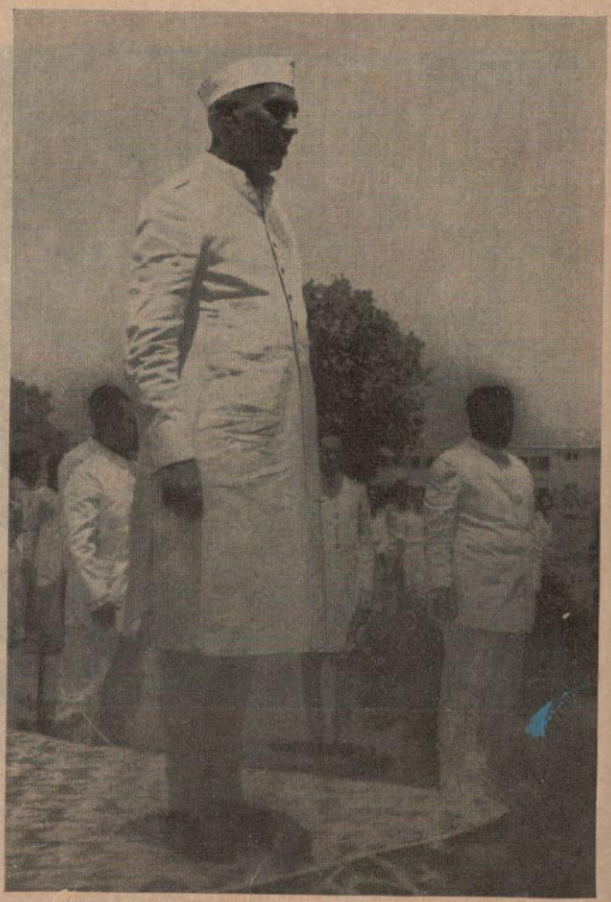
The streamlined façade of the New Building

A panoramic view of a Hall of Residence

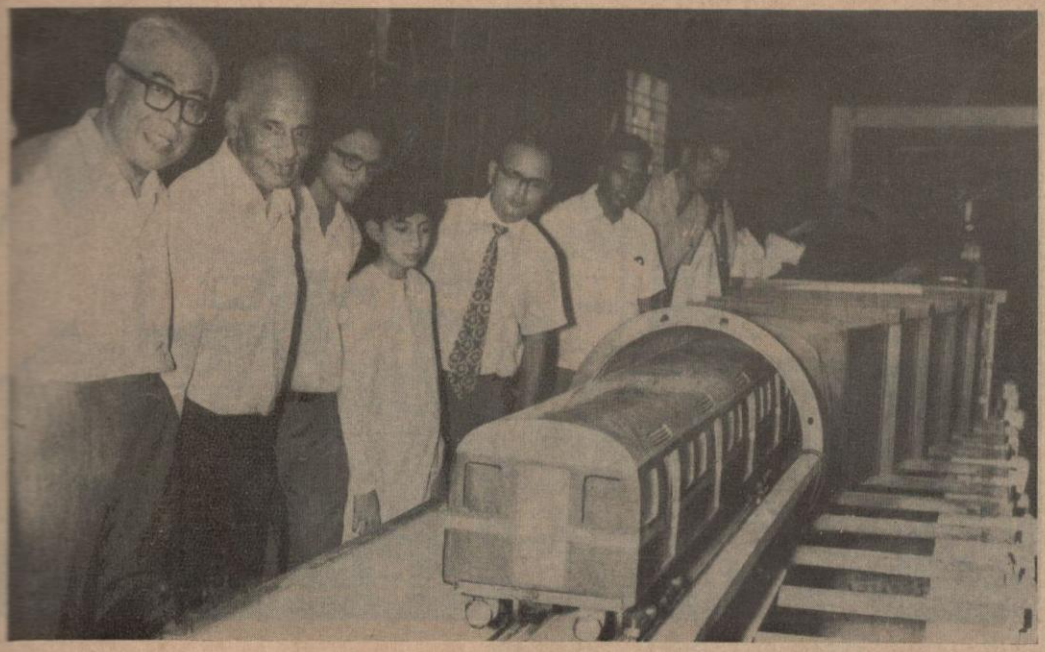


A corner of the Library Reading Hall

S. Radhakrishnan making a *bon mot*

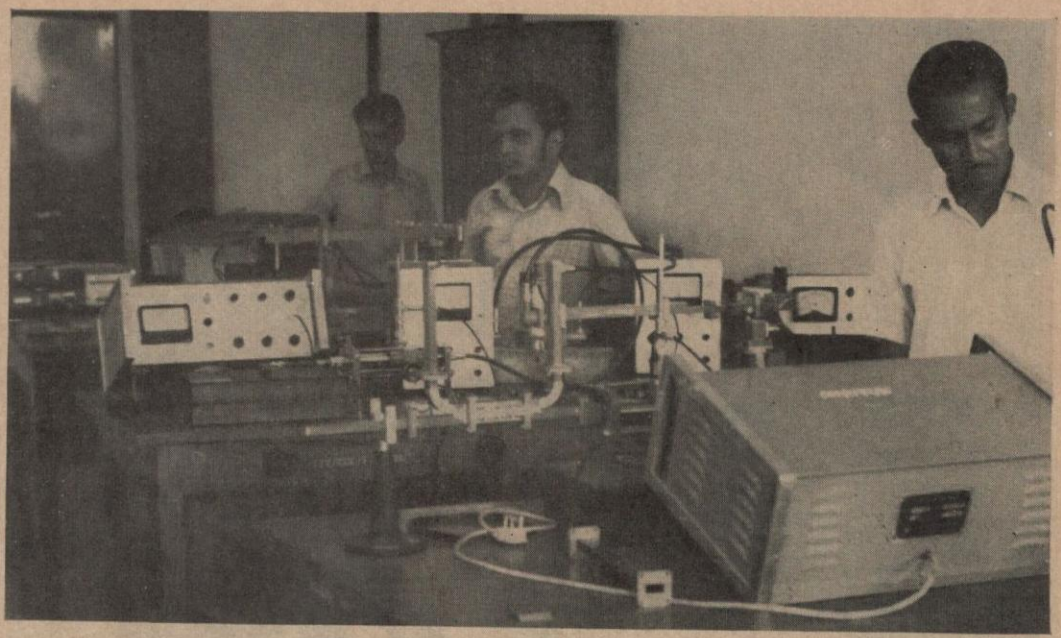


Jawaharlal Nehru inspecting
a march past by N.C.C. cadets

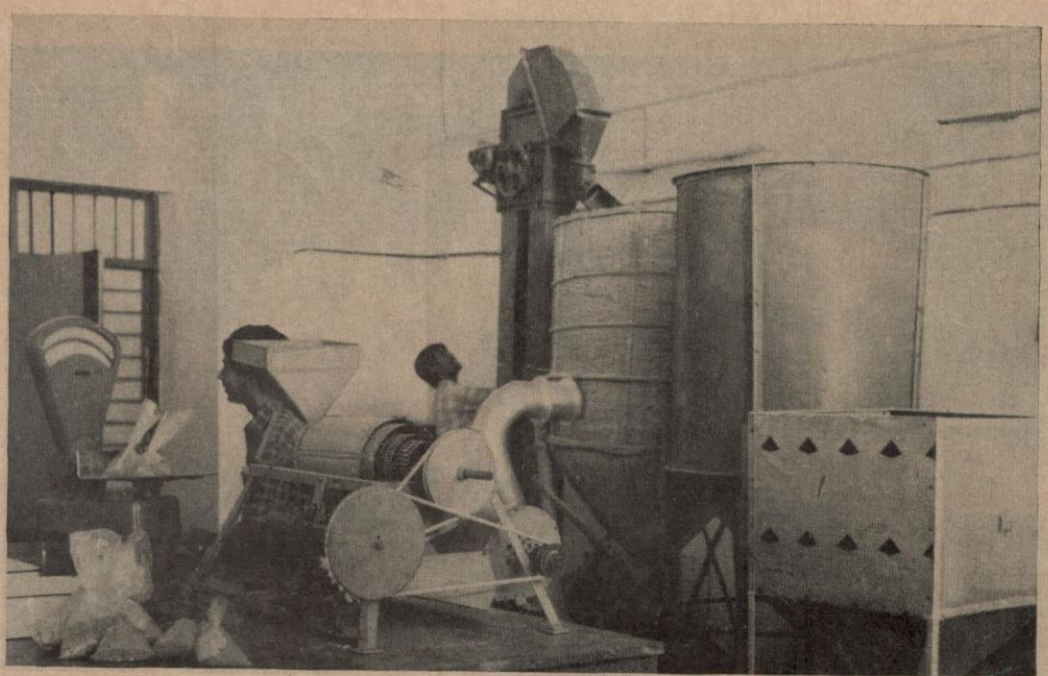


A model of Calcutta Tube Railway designed here

An architecture class in session



Microwave Laboratory at work

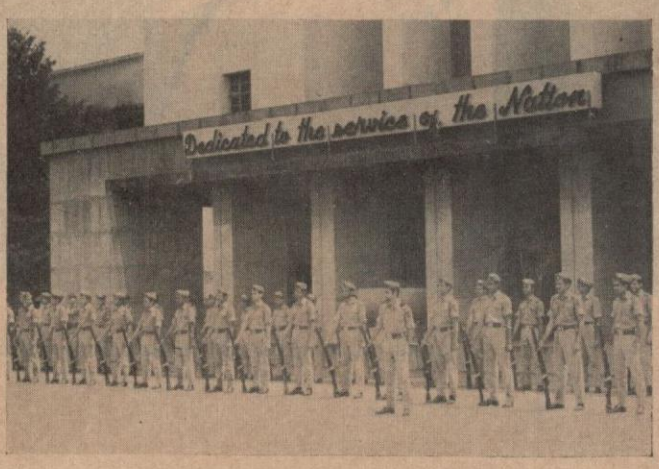


Drying Laboratory in the newly started Rice Process Centre

A clean vault

A music recital

A scene from a play staged by Technology Dramatic Society



N.C.C. cadets on parade

An idyllic view of the old India which still lives on the periphery of IIT campus

Photo by A. Appa R

A Résumé of Research Work

(1950–1975)

Department of Aeronautical Engineering

Founded in 1964, the department has carried out research and investigation in the following areas: (*a*) wing theory; (*b*) minimum weight design; (*c*) composite structures; (*d*) cascade testing; (*e*) some flow and heat transfer problems in fluid mechanics; (*f*) analytic method of Reynold's number extrapolation from model scale to flight; (*g*) theoretical and experimental studies on static and dynamic behaviour of plate elements having central openings and notches on the edges when subjected to tension; (*h*) construction of a universal test rig which will apply a non-uniform tension and compression on the structural element; (*i*) magnetohydrodynamics; (*j*) propeller performance.

The following instruments have been fabricated in the department: (*a*) Hele-shaw apparatus; (*b*) water tank for flow visualization; (*c*) three-component wind tunnel balance; (*d*) multitube manometer; (*e*) photoelastic bench; (*f*) models of wing plan forms.

Department of Agricultural Engineering

The research activities of the department, founded in 1952, range over agricultural process engineering, dairy and food engineering, farm machinery and power, soil and water conservation engineering and agricultural sciences.

Farm Power and Machinery

The emphasis has been on development of farm machinery for Indian farm conditions. Some of the notable interests have been the development of a potato harvesting machine, the development of a sugarcane planter, the design and fabrication of various types of rigid wheels for wet land, the determination of forces acting on tillage tools, the cutting energy required for harvesting different crops, and the energy required for intensive production.

Soil and Water Conservation Engineering

The research activities in this area have included irrigation and drainage, flow through porous media, salinity control and land reclamation. Studies on border irrigation, hydraulics of open dug wells, soil erosion due to rainfall, overland flow and the resulting erosion, investigations of percolation losses in paddyfields under submerged conditions, and investigations of consumptive use of water by paddy crop are some of the research areas of the department.

Dairy and Food Engineering

The research activities have centred on evolving new processing methods, determining properties of food materials, improving designs of processing equipment and investigating various design parameters, and have included milk and milk products, vegetables, grains and cereals.

Agricultural Processing

The main emphasis has been in the field of harvest and post-harvest technology of cereals, oil seeds and pulses. Notable work has been done on the influence of the period of harvesting (after flowering) on field yield and quality of grains. The research findings in respect of design of storage bins for the use

of small farmers have been accepted by the State Government to be popularized among the farmers. Research work has been carried out in the areas of harvesting, drying, and milling; studies have been undertaken on paddy and groundnut, development of husk-fired furnaces, utilization of by-products of food grains, etc.

Agricultural Sciences

The major contribution in the field of Applied Botany has been the pioneering work on the genetics and cytology of legume pulses and subsequent practical achievements through polyploid induction, wide hybridization and induced mutations. The origin of some of these crops like *Cajanus* has been established. Sustained work with radiations and chemical mutagens has helped to standardize the techniques of their use, and to evolve new varieties of economic importance.

The work on the quantitative characteristics of rice led to the discovery of two new high-yielding, early-maturing varieties of rice, IIT-60 and IIT-48. The importance of increasing genetic variation through artificial methods has been established and extended to grasses and oil-yielding crops in addition to legume pulses and rice. Cytological studies and investigations on the mode of reproduction of ornamental plants and grasses have thrown new light on their economic improvement through different breeding methods.

Research on the molecular architecture of chromosomes with the aid of the electron microscope, enzyme-cytochemical techniques and autoradiography, helped to propose a chromosome model to suggest that histones are responsible for chromosome coiling and that non-histones act as ligand macromolecules. A new class of collagen-like protein was discovered in eukaryotic cell nuclei which probably represents the backbone and accounts for some of the unexplained attributes of synapsis, breakage, recombination, etc. A new phenomenon of photo-enhancement was recorded through fluorescence microscopic studies. Signal contributions have also been made towards studies on the ultra-structure of nuclear membrane, differentiation during meiosis, origin and development of secondary xylem, etc. New facts of significance have also been obtained towards bacteria–plant symbiosis in root nodules, lipid metabolism in root-cap cells and synaptinemal complex.

The major problems of Agronomy on which work has been done relate to varietal evaluation, cultural, irrigational, and nutritional requirements of crops, testing of the suitability of fertilizer materials and weedicides, and prospects of multiple cropping under this agro-edaphic and climatic region. Research on crop physiology, seed production and storage, production environ-

ment and agro-socio-economic aspects is also in progress.

The section is actively associated with the State Agricultural Department of West Bengal in framing a Comprehensive Area Development project at Tamluk, and also with the Indo-German Fertilizer project.

In Soil Science, some of the notable achievements are: design, fabrication and testing of inexpensive soil moisture meters along with gypsum and teryline resistance units and thermocouple psychrometer for measuring water potential of soil and leaf, oxygen diffusion rate meter, pressure bomb apparatus for measuring leaf water potential, impact type ball-point penetrometer and double-ring core samplers.

It has been established that deep ploughing greatly increases the infiltration capacity of the lateritic soil and that straw mulch harrowing helps to maintain it. Infiltration rate has been observed to be exponentially and negatively related to soil moisture content. Increase in bulk density of soil increases soil strength and improves crop yield at an optimum density determined for different crops. A bulk density range of 1.60 to 1.80 gm om^{-3} in lateritic sandy loam soil has proved to be conducive to optimum growth yield of rice under submerged conditions. The most congenial seed bed for maximum wheat yield should maintain oxygen diffusion rate above 50×10^{-8} gm cm^{-2} min^{-1}. A submerged soil temperature regime of 37–25°C has been found to be optimum for rice growth. The depletion of soil moisture from 28 per cent to 7.2 per cent in sandy loam soil resulted in an increase of diffusion pressure deficit of rice leaf from 2.0 to 9.7 at which it starts wilting.

Normal germination of rice seeds could occur at an electrical conductivity (EC) of 4.55 m mhos/cm and was hindered beyond EC of 59.44 m mhos/cm. Among the rice varieties tested for salt tolerance, Tangra and Banshata were comparatively more salt tolerant than Taichung Native–1 or Noonabagra. Increasing the salinity levels suppressed the uptake of N, P and K by rice plants.

Department of Architecture and Regional Planning

Founded in 1952, the department has been engaged in pioneering research in the fields of architecture and planning. Some major topics of research and investigation are as follows: (*a*) climate in the evolution of urban form; (*b*) system of proportion; (*c*) urban continuity through diffusion; (*d*) regionalization and regional development of the coal-steel belt of India; (*e*) imageability in capital cities of India; (*f*) megalopolitan development along the Howrah–Amritsar axis; (*g*) colour in architecture; (*h*) central business districts in Indian cities; (*i*) the evolution of urban design in the Mohammedan period and onwards; (*j*) the impact of rapid industrialization on tribal traits and social values in some selected districts of Eastern India.

Services Rendered to Other Organizations

The department undertook the study of the Damodar Valley region jointly with the University of Calcutta and the University of Patna, at the instance of the Planning Commission. It also undertook major projects for Bhilai, Bhutan, Sikkim, Visva-Bharati, Rourkela and other Government and semi-Government agencies. The department has submitted a Master Plan Report for the development of Mokokchung town and the Mokokchung–Tuli–Chanki belt to the Government of Nagaland. The department has been commissioned to design (*a*) a 100-bed hospital for the DVC authorities at Dhanbad; (*b*) a 250-bed hospital at Kharagpur; (*c*) an administrative building for CMPDI, Ranchi.

Department of Chemical Engineering

The research and development activities of the department since its inception in 1951 have been of fundamental nature and industrial importance. Among the pilot plant scale studies conducted, the most notable achievement is the design, erection, commissioning and operation of a 100 gallon/day pilot plant for the production of synthetic oil and chemicals from coal by Fischer–Tropsch process. Departmental research activities under eight major areas of interest are as follows.

Mass, Momentum and Energy Transfer

Researches carried out in this area are on hydrodynamics of liquid jets, performance and design of ejector systems, atomization and entrainment characteristics of liquids, rheology and heat transfer characteristics of non-Newtonian suspensions, bubble and mechanical agitation of suspended solids, two- and three-phase flow dynamics, motion and mass transfer of liquid drops, and mass transfer in spray and pulsed absorbers and in bubble columns.

In studies on liquid, gas-liquid and gas-liquid-solid ejector systems, very high orders of transfer coefficients and interfacial area generation through mixing shock phenomena were obtained. Ejector systems proved highly efficient for mass transfer operations.

In studies on entrainment, two distinct mechanisms were identified for the formation of drops of entrainment in the bubbling and channelling zones, and correlations proposed for average drop size and quantity of entrainment. Single- and two-phase atomization characteristics of liquids were studied and equations developed for the drop size of atomization necessary for design of spray chambers and air-atomized oil burners.

A concentric-cylinder rotational viscometer was specially developed for measuring the apparent viscosity of rapidly settling non-Newtonian suspension and correlations developed. Studies were conducted on turbulent friction factor and rate of heat transfer for horizontal flow of suspensions in straight and curved pipes and in anulus, and slurry transportations through pipe lines and generalized equations proposed for design.

In bubble and mechanical agitation for suspending particles in liquids, a combined bubble-mechanical agitation was found more economical in respect of power requirements. For this study a differential torque-meter was developed. Pick-up velocities, gas-phase pressure drop, gas and solid hold-up and solid-liquid wettability parameter were evaluated in bubble and foam-bed systems; the proposed correlations are of considerable importance in design of industrial reactors using solid catalysts in suspension.

Drop dynamics and mechanism of mass transfer during formation, travel and coalescence were investigated for single and multiple drops moving in a continuous medium. Significant increases in mass transfer rate were attained with increased internal surface of drops, residence time of bubbles or interfacial area of oscillating liquid through pulsations in the gas and liquid phases. Models were developed for evaluation of drop size and surface-renewal time in oscillating drops in spray and pulsed absorbers and for mass transfer rates during and after formation of bubbles in bubble-columns.

Reaction Kinetics and Reactor Design

Basic information on the mechanism and kinetics of some important industrial reactions was obtained and suitable catalysts and rate equations developed for design of reactors. Investigations were carried out on vapour-phase oxidation of ethanol to acetaldehyde with air over crystalline silver catalysts, carboxylation of sodium phenate, thermal decomposition of sodium bicarbonate in fluidized beds and chemical absorption of SO_3 in dodecyl benzene alkylate in stirred reactors and bubble-columns. Process development studies were also made for recovery of sulphur from low grade pyrites in fluidized beds and production of useful sulphur chemicals from SO_2. An automatic recording thermogravimetric balance has been developed for studying reaction kinetics and a prototype supplied to Defence Laboratory.

Thermodynamics of Solutions

Researches in this area are mainly directed towards obtaining reliable vapour-liquid equilibrium data of miscible and partially miscible binary and ternary systems of industrial importance at atmospheric and high pressures for design of distillation columns, testing the data for thermodynamic consistency and developing their correlations.

Process Dynamics and Control

Transient step response of distillation columns was studied for operating parameters changed individually and simultaneously and their effects on time

constants of individual plates and overall column were evaluated. Multivariable and state-variable models of the column were developed considering strong interactions of column variables and suitable controllers synthesized.

Particle Technology and Mineral Beneficiation

The mechanisms of momentum, mass and heat transfer occurring individually or simultaneously in fluidized beds were studied in depth and the relevant transfer coefficients evaluated for many applications in design. Heat transfer from wall to particle and clouds of falling particles, drying of particles and particle growth in fluidized beds, applications of semifluidization technique, drying of granular particles like wheat and paddy in spouted beds, mixing of dissimilar particles and classification of particles in fluidized beds, etc., were some of the problems of special interest to industry.

Studies in hydrocyclones were carried out for separation of fine particles in suspension and correlations obtained for a rational design. A rotating tube classifier was developed for separation of very fine particles of dissimilar solids, and suitable models proposed for the particle trajectory for design purposes.

Grinding of high-ash coals and minerals was carried out to evaluate grindability and power requirements. Froth flotation studies were conducted for removal of silica from precipitated chalk, enrichment of low grade graphite, and beneficiation of high-ash coals and a number of minerals; optimum operating conditions were determined and suitable design equations developed for the kinetics of flotation. A process has been developed for extraction of copper up to 85 per cent from chalcopyrite and slags.

Petroleum Processing and Petrochemicals

Processes for utilization of heavier petroleum fractions to produce middle distillates and fuel oils which are in short supply in the country, treatment and recovery of waste tube oils, etc., have been developed and kinetics of some petrochemical reactions of industrial importance investigated.

Studies were carried out on vis-breaking of reduced crude for maximum yield of fuel oils, catalytic cracking of pressible waxy distillates and long residuum for middle distillates, urea-dewaxing for production of high quality jet fuels and phenol treatment of pressible waxy distillates for production of lubricating oils.

Reaction mechanisms and kinetics for the liquid-phase catalytic air-oxidation of toluene to benzoic acid, picolines to picolinic acids and xylenes to carboxylic acids were studied and process conditions optimized for maximum yield of products.

Coal Process Engineering

In view of the limited reserve of good-quality coal, intensive work has been carried out for the development of technologies for upgrading and efficient use of low-grade coals available in abundance in India.

Investigations were carried out on the improvement of the quality of lignites by froth flotation and other techniques, pattern of mineral matter distribution and grindability of Indian coals, froth flotation of coals for reducing ash content, effect of mineral matter on caking properties of coals and petrographic beneficiation of coals.

Research work was carried out on the kinetics of carbonization of low-grade coals and lignites, low temperature carbonization in fluidized beds, oxidation of weakly caking coals, effect of mineral matter on carbonization and briquetting, shock heating and hot briquetting of weakly caking coals without binders, production of synthesis and water gases from coals and lignites in specially designed autothermal fluidized bed gasifiers, and development of catalyst for Fischer–Tropsch and related synthesis for conversion of low-grade coals to synthetic oils and chemicals.

Combustion Engineering and Furnace Design

The researches carried out in this area are mainly on efficient combustion of solid, liquid and gaseous fuels for evaluation of combustion characteristics.

Investigations were carried out on the determination of the burning velocity and flame characteristics with shadow graph technique, dynamic flame method and high speed photography, atomization and combustion characteristics of liquid fuels with air-atomized burners, burning of coals on grates, and calcination and heat transfer characteristics in a rotary kiln.

Department of Chemistry

Significant contributions in the following fields have been made during the past twenty-five years.

Organic Chemistry

(*a*) New methodologies for the synthesis of biologically important molecules; (*b*) mechanistic and stereochemical studies on organic reactions, including cationic cyclization leading to polycyclic systems; (*c*) development of new reducing agents for stereoselective reduction of carbonyl compounds and asymmetric synthesis.

Biochemistry

(*a*) Analytical biochemistry and biochemistry of food grains; (*b*) Enzyme chemistry and kinetics; (*c*) development and design of preservative chemicals and containers for minor food crops of the region.

Solid State Chemistry and Catalysis

(*a*) Physicochemical studies involving heterogeneous catalyst systems; (*b*) chemisorption, kinetics and solid-solid reactions; (*c*) application of DTA, TGA, conductivity measurements and Mossbauer Spectroscopy in solid systems.

High Pressure and Technical Gas Reactions

(*a*) Development of processes for production of industrially important chemicals from indigenous materials; (*b*) investigations on the activities of various catalysts under high pressure; (*c*) kinetic and mechanistic studies of reactions under pressure.

Chemical Kinetics and Catalysis

(*a*) Development of catalysts and kinetic studies in vapour phase catalysis in fixed and fluidized bed; (*b*) liquid phase hydrogenation and oxidation, ammo-oxidation of organic compounds; (*c*) dehydrosulphurization of petroleum.

High Polymer and Rubber Technology

(*a*) Development of new catalyst and initiator systems for vinyl polymerization; (*b*) kinetics and mechanism of polymerization; (*c*) vulcanization and compounding of rubber and studies on metal-polymer composites.

Theoretical Chemistry

Theoretical studies on molecular structure and molecular spectra using various quantum chemical methods such as PPP, CNDO, SVEM, etc.

Electrochemistry

(*a*) Behaviour of reversible electrode systems in solvents of high dielectric constant; (*b*) development of new electrodes; (*c*) thermodynamics of non-aqueous systems containing strong and weak electrolytes; (*d*) theoretical investigations on electrode potentials; (*e*) electrode kinetics involving fuel cell reactions; (*f*) electrochemical processes at noble metal and dropping mercury electrodes.

Inorganic Chemistry

(*a*) Fluoro complexes of rare transition elements; (*b*) chemistry of manganese, rhenium, thorium, uranium and rare earth complexes; (*c*) multi-metal centre cluster compounds; (*d*) electrophilic substitution reaction on metal chelates; (*e*) homogeneous catalytic reactions with metal chelate as catalysts.

Department of Civil Engineering

Soil Mechanics and Foundation Engineering

Investigations are in progress in the following areas: (*a*) behaviour of batter piles and pile bents in sand; (*b*) rheology of soil consolidation; (*c*) static and dynamic bearing capacity of footings on sand; (*d*) pile groups in sands; (*e*) correlation of cone penetration resistance with bearing capacity and settlement; (*f*) stability of eccentrically loaded footings on sand.

Research has been carried out on topics like (*a*) dynamic behaviour of embedded ribbed foundations; (*b*) foundations for heavy machines; (*c*) earth pressures against curved contract surfaces; (*d*) behaviour of different foundations under combined loads; (*e*) strength and deformation characteristics of soils under widely varying conditions.

The section has extended considerable expertise to design and construction organizations, like Hindusthan Steel, Indian Railways, the IAF base at Kalaikunda, defence organizations, CMDA, etc.

Public Health Engineering

Investigations on different aspects of filtration and settling floc suspensions have been carried out.

Laboratory work to study the formation of zoogleal mass in the activated sludge process has been done. Trickling filter, operation and process design are being investigated for sewage treatment.

Iron removal studies have been made for the campus water supply from tube-wells.

Structural Engineering

Intensive experimental studies on reinforced and prestressed concrete simple and continuous beams have been done. Studies on RC columns, portal frames and reinforced concrete deep girders have been completed. Shear failure of RC beams has been studied very extensively. Strength of RC beams under flexure, transverse shear and torsion has also been studied. Experimental studies on RC plates and folded plate structures and shells of various shapes

have been made. Development of high stiffness and light weight sandwich structures has been investigated.

Strength and characteristic behaviour of steel frames and members subjected to flexure and shear are being studied in addition to the studies of response of structural members under dynamic loading. Experimental work on infilled frames and encased continuous beam and RC beams under combined stresses is in progress.

Highway Engineering

Experimental studies on the strength, deformation and degradation characteristics of highway materials and bituminous materials are being made extensively.

Experimental investigation of soil stabilization for highway sub-grade has also been made.

Temperature stresses on highway concrete pavements have been studied theoretically and experimentally.

Hydraulic Engineering

Flow characteristics in open channels and conduits have been extensively studied. Seepage flow characteristics in porous media for two-dimensional and three-dimensional cases have been investigated theoretically and experimentally.

Shear flow characteristics under various conditions in open channel have been experimentally investigated. Flow characteristics in river models have also been studied. Vorticity has been studied theoretically and experimentally. Wave characteristics in open channels have been theoretically formulated and experimentally studied in the laboratory.

Department of Electrical Engineering

The research activities of the department began around 1956 with the study of electromagnetic phenomena in solid iron. Mainly three aspects of the problem were studied: the effects of eddy currents and flux rise in solid cores subjected to impact excitation, evaluation of eddy current loss and mechanical forces when a block of iron is subjected to alternating and travelling fields taking into account the nonlinear nature of the B-H curve. The investigations helped in obtaining original closed form solutions for eddy current loss in solid iron, and torque in solid rotor induction motor under the assumption of a limiting nonlinear B-H curve. Moreover, an insight into other associated problems gained during the earlier investigations helped further research. Some of the problems studied were (*a*) flux rise in solid magnetic circuits with air gap; (*b*) evaluation of eddy current losses in thin ferromagnetic sheets taking the true B-H curve and distortion of the field quantities into account by numerical/graphical methods; (*c*) internal impedance of ferromagnetic conductors carrying alternating currents; (*d*) pulsation losses due to 'deeply penetrating' field in pole laminations; (*e*) performance of induction motors with hollow and segmented mild steel rotors; and (*f*) performance of induction motors with solid rotors with axial slits with and without copper fillings. In recent years studies were made on end-effects in solid rotor induction machines, evaluation of torque in eddy current brakes and preparation of normalized loss curves for materials with different B-H curves.

In the field of electrical machines, attempts were made to develop multi-speed (up to 3 speeds) single phase induction motors using pole amplitude modulation techniques. Performance of reluctance motors with unlaminated rotors was also studied. Presently work is in progress on application of thyristors in the speed control of solid rotor induction motors, single phase capacitor motors and polyphase induction motors using cycle converter principle.

In control engineering, considerable work has been done in the field of nonlinear control systems such as determination of the closed-loop frequency response of nonlinear systems, investigation of the stability of solutions (using incremental frequency response method), analysis of almost periodic response

of self-oscillating systems and forced harmonic and subharmonic oscillations in relay control systems. A 'universal chart' has been developed which facilitates rapid study of all the above aspects with relative ease as compared with several other traditional methods. Studies were also undertaken on the use of IDF and DIDF methods in nonlinear control systems. Currently an in-depth study of IDF technique is being carried out regarding its mathematical validity. Studies have also been carried out on control systems with time-varying parameters.

Investigations are in progress in the field of optimal control of distributed parameter systems, and nonlinear systems, as well as in the application of singular perturbation techniques to optimal control problems. Recently investigations have been taken up in the field of system identification.

In power systems engineering earlier investigations dealt with the study of contact resistance of static and sliding contacts of different geometrical shapes under DC and AC conditions. The introduction of a postgraduate course in Power Systems Engineering in the year 1964 helped a great deal in widening the areas of research work. Studies were made to investigate the effect of control equipment on the performance and relative stability of alternators forming part of a power system. Generalized Mitrovic's method has been used in the investigation which covers, in addition to the single-machine system, two-machine and multi-machine systems. The control equipment includes both voltage regulator and governor control.

Investigations have been carried out on the application of piecewise load flow solution techniques to typical power system networks. The study includes the comparison between the piecewise methods and single piece method in terms of core storage requirements, computation time and the interactions required. At present work is in progress on optimal load scheduling and piecewise methods applied to load scheduling. Work has also been initiated in the field of high voltage engineering which includes the corona effect of cross magnetic field on the breakdown strength of solid, liquid and gaseous dielectrics.

Department of Electronics and Electrical Communication Engineering

Researches in the department have been carried out mainly in the following areas:

Microwave Antennas and Circuits

Work on slot radiators, aperture radiators and microwave circuits started in 1955; microwave test bench components including microwave bandpass filters have been developed.

Communication Systems

Work started in 1953. Specific areas—pulse slope modulation, delta modulation systems and other pulse modulation techniques; two research schemes on speechband compression and broadband communication systems have been completed and some of the prototypes developed in the department are being fabricated for use by the Ministry of Defence.

Control Systems

Work started in 1961. Specific fields—auto follow systems, digital control systems and adaptive control systems. Schemes on the development of two-phase servo motors and AC tacho generators were successfully completed for the Ministry of Defence.

Bio-electronics

Work on ECG and EEG recorders and electromyographs is in progress.

Sub-surface Communication

Work started in 1966 and some sub-surface antennas were developed for both transmission and reception.

Pattern Recognition

Work has been started on pattern recognition of English and Hindi characters, and on machine recognition of images.

Department of Geology and Geophysics

From a modest beginning in 1951, the department has extended its research activities in a number of fields in earth sciences. Pioneering work in India has been done in metamorphism and geochemistry of high grade rocks, volcanology, Quaternary geology and geomathematics. Research in experimental petrology has been initiated. Investigations on the environmental framework of different mineralized belts and the geochemical relation among ore minerals have established this department as a leading centre of ore geology. Significant studies on the sedimentary environment of metamorphosed Precambrians, Cuddapahs, Gondwanas of a number of east Indian coalfields, and Himalayan Tertiaries of the Simla Hills and of modern sediments have been undertaken. Studies on some theoretical aspects of structural geology and extensive work on regional structures in relation to metamorphism in the Precambrian and Himalayan terrains have placed this department in the front rank of structural geology schools in India. Among other geologic studies the following are noteworthy: (*a*) equilibrium relations among common metamorphic minerals of variable composition; (*b*) evolution of Quaternary stratigraphic techniques and establishment of Quaternary formations in eastern India; (*c*) geologic data processing in relation to mineral exploration; (*d*) thermal metamorphism of sulphides; (*e*) foraminiferal biostratigraphy, palaeobiometrics, palaeoecology and morphologic studies of foraminifers, ostracods and bryozoans; (*f*) environmental relations of clay minerals; (*g*) hydrogeological studies of alluvial and coastal areas; (*h*) engineering geology of beach erosion.

In the Geophysics section, significant work has been carried out in seismology, gravity and magnetics, electrical and electromagnetic methods and in nuclear methods. Particularly notable amongst these studies are: (*a*) spectral analysis of seismic waves, model seismic studies, devising of a single-channel seismic instrument for engineering applications; (*b*) development of analogue techniques for simulation of geological bodies as an aid to interpretation of gravity data; spectral analysis of gravity and magnetic anomalies of regularly shaped geologic bodies; interpretation techniques for mining geophysics and

computer applications for such studies; (*c*) development of a new method—the Central Frequency Sounding method—for groundwater and mineral exploration; theoretical studies on applications of electrotelluric methods for determining the basement structures, and application of induced polarization in mining problems; (*d*) thermoluminescence studies of quartz and other minerals, particularly for radiometric age determination and identification of clay minerals; and pulse-height techniques for estimation of U, Th and K in different types of rocks; (*e*) application of electrochemistry in borehole geophysics.

Department of Humanities and Social Sciences

Economics

Significant work has been done on the following problem: Wage incentives and productivity.

Work is in progress on the following: Returns of educational investment in India.

English Literature

Notable research work has been done on the following: (*a*) Metaphysical tradition in English poetry; (*b*) American Negro fiction; (*c*) Shakespeare's prose; (*d*) Hemingway.

Work is in progress on the following: (*a*) Christopher Fry; (*b*) Huxley as a literary critic; (*c*) Isherwood's novels; (*d*) Scott Fitzgerald.

History

Significant work has been done on the following: Indian revolutionaries in America, 1909–1918.

Work is in progress on the following: International politics and Indian national movement, 1939–1947.

History of Science and Technology

Notable work has been done on the following: An analytical history of the Meson theory of nuclear forces since 1935.

Linguistics

Notable work has been done on the following: A contrastive analysis of the phonological structures of English and Bengali.

Philosophy

Distinguished work has been done on the following: Knowledge of self.

Psychology

Notable work has been done on the following: (*a*) union membership,

employee attitude and productivity; (*b*) supervisory behaviour and productivity; (*c*) control and problem of effective supervision; (*d*) educational high-achievers and low-achievers; (*e*) job satisfaction and employee productivity, turnover and absenteeism.

Work is in progress on the following: (*a*) organizational behaviour; (*b*) vigilance and other human engineering problems; (*c*) noise and its effect on performance; (*d*) investigation on personality problems by projective tests; (*e*) analysis of JEE question papers with reference to performance and prediction; (*f*) verbal learning.

Sociology

Work is in progress on the following: Growth-point study for urban development.

Material Science Centre

Organizationally, the Centre is inter-disciplinary, oriented towards group research programmes on selected projects. The initial plan envisaged four divisions of the Centre, viz. (*a*) Metals and Alloys and Composites, (*b*) Semiconductor and Allied Material, (*c*) High Polymer, (*d*) Ceramics. The Centre launched its activities in 1970 by setting up the Metals and Alloys division with the help of equipment procured from the USSR under an Indo-Soviet bilateral agreement.

Projects Undertaken at the Centre

(*a*) Optimization of the case depth of Mn-Cr carburizing grade steel for heavy duty gears and pinions—for TELCO; assignment completed. (*b*) Grinding media for ball mill—in collaboration with Electro Steel Co., Calcutta; the first part of the project (120 mm size) has been completed and the product is being marketed. (*c*) Reducing the defects of heavy duty crane wheel castings —work taken up in collaboration with Bhilai Steel Plant; assignment completed. (*d*) Tarnishing problems of bronze wire mesh—a problem of Shalimar Wire Industries; project completed. (*e*) Optimization of resin-bonded sand mixtures for shell process—a project started with collaboration of TELCO. (*f*) Study of inclusions of special steels—a joint venture with Alloy Steel Plant, Durgapur; the first phase has already been completed. (*g*) Study on the weldability of cast Hadfield steel—in collaboration with Bhartia Electric Steel, Calcutta. (*h*) Development of glass and glass ceramics from Bhilai blast furnace slag. (*i*) Development of luminiscent materials with a CSIR grant. (*j*) Synthesis of new low-loss insulating/semiconductive thermo-resistant polymers. (*k*) Development of high polymeric adhesive formulations and oil resistant materials. (*l*) Metallopolymer composites—an inter-disciplinary scheme taken up jointly with the Chemistry Department. (*m*) Development of high strength iron and aluminium base alloys—a project which has been awarded a large NCST grant as a nationally important project. (*n*) Development of self-setting and fluid self-hardening sand mixtures using indigenous raw materials supplied by Bhartia Electric Steel, Swastik Mills and Greaves Foseco. (*o*) Utilization of power plant fly ash—a joint collaborative programme recently undertaken with Talcher Thermal Plant of Orissa. (*p*) Sintered steel from ferrographite composites and development of new sinter forging technology.

Department of Mathematics

During the last twenty-five years the department has made some progress in the theoretical aspects of continuum mechanics, mathematical statistics, numerical analysis and high speed computation, theory of relativity and cosmology, and functional analysis. Some results of theoretical investigations in continuum mechanics have been followed up by experimental investigations in the Civil, Mechanical and Aeronautical Engineering Departments of this Institute.

Research activities in the department can be broadly classified as follows: (*a*) mathematical methods of elasticity, thermoelasticity and plasticity; (*b*) flow and heat transfer in Newtonian and non-Newtonian liquids; hydrodynamic lubrication; (*c*) hydrodynamic and hydromagnetic stability; (*d*) gas dynamics; (*e*) statistical inference; (*f*) graph theory, psychometry and econometrics; (*g*) operations research; (*h*) relativity, cosmology and unified field theories; (*i*) numerical analysis and high speed computation; interval analysis; (*j*) operator theory; (*k*) geometry and models.

In the field of elasticity and plasticity, investigations in the area of finite strain theory have helped in explaining the existence of axial stresses in specimens subjected to large twist, hitherto unexplained by infinitesimal strain theory. Some dynamical problems of thermo-elasticity and magneto-elasticity have been solved, and the results have a bearing on geophysical phenomena. In the realm of fluid mechanics, the investigations in the boundary layer flow with suction and injection on solid boundaries have applications to aerodynamic problems associated with reduction of drag and augmentation of lift on aerofoils. The growth and decay of discontinuities in a gas have been investigated with reference to shock-wave phenomena. Flow of non-Newtonian liquids in elastic tubes obeying Hooke's law has been studied in detail and the results are likely to be of importance in connection with flow of blood through arteries. Studies on magneto-hydrodynamic free convection have shown that a magnetic field of moderate strength can go a long way in alleviating the rate of heat transfer from solid surfaces. The investigations carried out on hydromagnetic stability have a bearing on the problem of controlled thermonuclear reactions.

In the field of numerical methods and high speed computation, significant

advances have been made in the use of collocation, Ritz, Galerkin and finite difference methods in solving a large number of boundary and initial value problems.

In mathematical statistics, the effect of non-normality on some important statistical tests and on control charts has been studied. In the field of industrial statistics, Bayesian inference techniques have been applied to some problems of reliability. In the domain of operations research and graph theory, some new algorithms have been derived for the travelling salesman and some other integer programming problems. Several enumeration problems in graph theory have also been solved. Some models based on multivariate exponential distribution have been developed and their applications to reliability of systems have been studied.

In the theory of relativity, investigations in the following topics have been carried out: (*a*) unified field theories of Einstein and Schrödinger; (*b*) scalar Meson fields; (*c*) charged scalar and vector Meson fields; (*d*) Brans-Dicke theory; and (*e*) embedding space-times.

Department of Mechanical Engineering

Extensive research work has been done by the department in the following fields: (*a*) characteristics of Indian foundry sands; (*b*) comparison of predicted and measured performance of steam turbines; (*c*) experimental investigation of effect of pulsation and swirl on combustion characteristics of fuels; (*d*) optimum parameters for best performance of diesel engines with minimum emission of pollutants; (*e*) stress analysis of helical gear teeth; (*f*) dynamics of shrouded turbine blade packets; (*g*) hydraulic and pneumatic transporation of solids through pipes; (*h*) dynamic stresses in overhead cranes; (*i*) fatigue failure of crank-shaft in diesel engines of locomotives; (*j*) technique for evaluation of wear in cutting tools; (*k*) studies in explosive forming of metals; (*l*) studies in aerostatic, hydrostatic and porous bearings; (*m*) optimization of design parameters of rolling-mill stands; (*n*) smokeless burning of coal; (*o*) welding of plastics; (*p*) basic studies in electric welding; (*q*) studies in industrial systems; (*r*) harnessing of power through wind-mills; (*s*) development of models for industrial mechanisms; (*t*) studies on compressible and incompressible flow and thermal boundary layer.

Several industrial research projects have been undertaken by the department in the recent past. They include: (*a*) chatter in a supercut lathe; (*b*) design and fabrication of an anechoic chamber and shaking tables; (*c*) calibration of torsion meter in a tug; (*d*) torsional vibration in diesel engines; (*e*) heat transfer and thermal loading of internal-combustion engines; (*f*) ventilation system design for Metropolitan Tube Railway project; (*g*) design and development of pneumatic conveying system; (*h*) structural vibration in the sintering plant of Rourkela Steel Plant; (*i*) design, development and experiments on a blower.

Department of Metallurgical Engineering

Notable achievements in the field of research are as follows:

Physical Metallurgy

(*a*) A method of determination of retained austenite by D.T.A. has been developed.

(*b*) From the study of the tempering behaviour of chromium steels under creep, an explanation has been furnished to account for all effects observed on the basis of matrix depletion in carbon and the alloying elements due to enhanced precipitation, strain enhanced diffusion and the mechanisms of the reaction.

(*c*) Development of a maraging steel by substituting nickel for manganese.

Oxidation and Corrosion

The department has carried out pioneering work on the study of oxidation growth kinetics under electric field. The effect of alloying elements in low temperature tarnishing has been explained in a new light. Transition of tarnishing process from one rate equation to another has been verified experimentally.

New theories have been proposed for studies on stress-corrosion cracking behaviour of alpha brasses, on (*a*) transition of the fracture mode, (*b*) initiation and propagation of crack. It has been shown that the thickness of the film developed during progress of stress-corrosion has no relation to the susceptibility of stress-corrosion cracking.

Extractive and Process Metallurgy

The department has developed a non-blast-furnace method of extraction of lead for rich localized deposits where application of the blast-furnace method is not feasible or economic.

In studies on the process metallurgy of steel, progress has been made in the following areas: (*a*) kinetics of fluidized bed reduction of solid oxides; (*b*) kinetics and mechanism of high-temperature steel-making reactions; (*c*) correlation of structure and physical properties of $CaO–SiO_2–Al_2O_3–MgO$

slags; (*d*) extraction of iron powder from low grade laterites; (*e*) transport phenomenon in melting processes.

Mechanical Metallurgy

Laboratory studies on different thermo-mechanical treatment for improvement of properties of metals and alloys have shown that with treatment such as stress-aging the mechanical properties may be improved without affecting considerably the conductivity of the metals. From the measurement of activation energy, and electron microscopy of deformed specimens it has been shown that for low-melting-temperature superplastic alloys the controlling phenomena for superplasticity are the grain boundary rotation and shear. Dispersion of superfine oxide particles in metal-matrix by the co-precipitation technique has been successfully achieved, enhancing strength at low as well as high temperatures. In order to carry out sophisticated testing in mechanical deformation a tensile testing machine has been designed and fabricated. This machine is a versatile hard-beam type. The tests that can be performed with this equipment are: tensile tests with constant cross-head speed, tensile tests at different constant strain rate, creep tests under constant load, as well as constant stress and relaxation tests. These tests can be conducted at different temperatures and other conditions of testing. It provides automatic recording of stress-strain curves and the time-elongation curves during creep testing.

Foundry Metallurgy

(*a*) An explanation has been furnished for the formation of spheroidal graphite in cast iron.

(*b*) A new hypothesis for the modification of hyper-eutectic aluminium-silicon alloys explains all observed facts associated with the phenomenon.

Department of Mining Engineering

Investigations and research have been carried out in the following areas.

Ventilation

(*a*) Studies on propagation of ultrasonic waves through methane-air mixtures. (*b*) A thermoelectric attachment to a flame safety lamp was devised for estimating methane concentration. (*c*) Aerodynamic model studies on the resistance of mine airways supported with various types of timber sets. (*d*) Model studies on the aerodynamic drag and piston action of running trains in tunnels—a consultancy project on the ventilation system for the Calcutta underground railway.

Explosibility of Coal Dusts

Studies on the glow temperatures of coal dusts of Raniganj coals, the lower explosive limit, ignition temperature, minimum ignition energy, maximum explosion pressures and rates of pressure rise for different particle sizes, inert and volatile contents.

Rock Mechanics

Studies on (*a*) the physico-mechanical properties of mine rocks from various metal and coal mines of India; (*b*) drillability of some Indian rocks and minerals by rotary and percussive drilling; (*c*) abrasiveness of mine rocks and ores; (*d*) blasting mechanics using slurry explosives in cement-mortar models.

Mineral Economics

Techno-economic studies on the optimum exploitation of iron ore resources of India.

Mine Systems and Management

Maintenance of open-cast equipment in Indian mines, and rational planning and control methods.

Investigations on (*a*) optimization of transport systems for sand and coal in the Jharia coalfield; (*b*) long- and short-term production-planning of a group of mines using modern O.R. and computer techniques; and (*c*) a management information system for a large coal-mining enterprise.

Department of Naval Architecture

The first of its kind in the country, the department was established in 1952 to train naval architects for Indian shipyards, shipping companies, fisheries and the navy.

Some of the interesting topics on which research work has been conducted are as follows: (*a*) A new technique to overcome the difficulty of stimulation of turbulent flow over ship models has been developed. An 'acceleration-deceleration' method was attempted for turbulence stimulation by accelerating the model, followed by deceleration, before uniform towing speed of model was reached. In another problem, investigating the form resistance of ships, use was made of variation of temperature of tank throughout the year. (*b*) Two techniques were attempted for solving the problem of model resistance. One was to use very small ship models in a special towing tank filled with liquids of various viscosities. The other was to use artificially roughened ship models to obviate Reynolds number dependence of the model resistance, and a rough model technique was proposed for this purpose. (*c*) An interesting study on the design, construction and operational aspects of floating docks was made. (*d*) Studies on the economics of ship construction were also undertaken. (*e*) Several hydrodynamic problems in the fields of boundary layer and hydrodynamic stability have been investigated. (*f*) A ferro-cement boat is being constructed in an attempt to use non-traditional material for building inland craft.

Department of Physics and Meteorology

Research activity in the department falls into two broad groups, theoretical and experimental. In theoretical physics, contributions to nuclear physics, X-rays and solid-state physics have been notable. The nuclear theory group has carried out investigations on the various properties (binding energy, the photo-disintegration integrated and bremsstrahlung-weighted cross-section, muon capture rate and the electromagnetic form factor, etc.) of the few nucleon systems (H^2, H^3 and He^3, He^4 and Li^6) using mainly the relativistic velocity dependent potential of Nestor *et al.*, 1968. The results are in good agreement with experiment, so that so far as the nucleon systems are concerned it can be asserted that the velocity dependent nuclear potential has gained validity. The equivalence of any two nuclear potentials in integrated cross-section calculations has been successfully explained on the basis of the range-depth relationship of the nuclear potential.

The solid-state physics group has introduced two new Gruneisen parameters and has investigated their effect on thermal properties. A new model for the lattice dynamics of crystals which satisfies the equilibrium conditions of the crystals has been proposed for the study of the thermal properties of crystals. Investigation has also been carried out on electronic states and allied properties of condensed matter and on atmospheric absorption.

The experimental solid-state physics group has carried out significant studies in colour centre, luminescence (the oldest areas of research in the department), thermoluminescence, after-glow decay and energy transfer process. Pioneering studies have been made in growing single crystals (like pure and doped alkali halides) from melt by Kyropoulos method. Extensive studies on the dielectric properties, electrical conductivities and optical properties of diverse materials with and without X-ray irradiation, have produced valuable results on the dominance of space charge polarization at high temperature and on their defect states. Studies on AC field treated alkali halides with X-ray irradiation gave useful information on the defect state of such crystals. Work done in the field of X-rays and structure of matter has been recorded separately.

The group on magnetism has investigated the thermal properties of a

number of magnetic insulators and the results have shown many interesting phase-transition characteristics. Galvanomagnetic properties of a number of magnetic conductors have also been examined. The anomalous variation of conductivity Hall coefficient and magneto-resistance has been interpreted on the basis of the s-d interaction model.

In the semiconductor laboratory, the youngest one in the department, a new method has been developed to prepare an infrared sensitive photoconductive and photovoltaic detector.

The department has fabricated from indigenous sources the following apparatus: a furnace to grow single crystals from melts by the Kyropoulos method; a photoelectric scanning device for recording after-glow decay, study of luminescence and thermoluminescence spectra and energy transfer process; a multipurpose vacuum chamber and sample holder and a demountable cathode-ray tube for radiation damage and other studies of phosphors by low-energy electrons; a magnetic susceptibility balance; a rotation magnetometer; an instrument for the measurement of conductivity by the electrodeless method and a small single-focussing mass spectrometer; a gradient furnace (Stober method) for growing single crystals of alkali halides and a cryostat for measuring galvanomagnetic properties of semiconductors.

Rice Process Engineering Centre

Research work of the Centre has been directed mostly towards problem areas at the farmers' level. Research projects to determine the optimum stage for harvesting paddy in farmers' fields were undertaken in collaboration with the State Governments of Tamil Nadu, Andhra Pradesh, Bihar and West Bengal.

A recirculating dryer was designed and developed for drying the paddy harvested in the rainy season. The dryer, which is simple to operate, has become quite popular not only for the paddy crop but also other cereals and oil-seeds. The right to manufacture the RPEC dryer has been purchased by six manufacturers in different parts of the country, and the National Seeds Corporation is using the dryer extensively in drying seeds in their seed-processing plants. Efforts in the direction of developing a mini-rice-mill, a parboiling tank and storage unit suitable at the farmers' level are continuing. An agro-socioeconomic survey of a village in West Bengal was made to study resource availability and its interaction with new technology of production and processing. With this background the Centre is participating in the IIT–JNU collaborative research project on integrated Rural Area Development with the object of developing village-based processing industry for all agricultural products and increasing the farmers' income thereby.

The Centre has also been actively associated with the commercial rice-milling sector in improving the equipment and processes used in the modern processing method. Numerous projects demonstrating the effectiveness of modern technology in rice-milling have been conducted at different rice-mills in the country. The effectiveness of a suitable aeration system for rubber roll shellers and cone polishers was demonstrated at a rice-mill in Midnapur. The design of an RCC parboiling tank was undertaken in collaboration with the Civil Engineering Department. The tank is being used commercially because of its low initial cost and high corrosion resistance. A technique for drying parboiled paddy by using mechanical dryers was developed which has found its use in most of the commercial paddy-drying installations.

The Centre through its consultancy service has made its expertise available to organizations such as the Food Corporatoin of India, the National Seeds Corporation, the National Cooperative Development Corporation, the Gov-

ernments of West Bengal, Bihar, Orissa, Andhra Pradesh and Tamil Nadu, the Central Rice Research Institute, Cuttack, State Agricultural Universities, numerous rice-millers, rice-mill manufacturers and rice-bran-oil extractors. The Centre has also participated in various evaluation committees appointed by the Government of India and the International Rice Research Institute, Philippines.

School of Research in X-rays and Structure of Matter

The research activities and achievements can be catalogued as follows:

Crystal Structure Analysis

The direct method of crystal structure analysis has been improved by developing a step-by-step technique of determining phases through the application of the Sayre–Cochran–Zachariasen relation in combination with Woolfson's test.

Lattice Defects in Metals and Alloys

Evolving a procedure for determining the background level of the intensity profile systematically and introducing TDS corrections, a method of distinguishing between different types of defect profiles and hence of separating different types of defects, has been developed. Also an improved, single-line technique has vastly helped the study of defects in diverse materials and forms, particularly in thin films.

Diffraction by Non-linear Lattices

An improved and generalized treatment for diffraction by non-linear lattices has been evolved.

X-ray Study of Minerals

Besides applying the line profile technique and other methods mentioned above to some problems of clay minerals, a simple camera for studying fibrous minerals in the wide-angle region has been designed. A new method for identification and quantitative estimation of inorganic components in coal has been worked out.

Lattice Vibrations and Physical Properties of Crystals

Debye characteristic temperature and its variation with temperature, composition and defect contents for several metals and alloys have been studied through a new approach. Significant contributions have been made

in investigation on Gruneisen relation and coefficients of anharmonicity in lattice vibrations.

Low-Angle Scattering

An apparatus, which gives more satisfactory results and is capable of very high resolution, has been constructed for studying low-angle scattering from metal foils, metal wires and biological fibres.

Besides, significant results have been obtained from investigations on X-ray topography *vis-à-vis* crystal imperfections and on microwave and laser analogues.

An Approach to Science and Technology Planning

A. K. Malhotra

Introduction

Science policy is essentially concerned with the optimal use of science and technology as agents of economic growth and social development, taking the latter to include the advancement of knowledge. According to the definition adopted by the UNESCO, it may also be defined as 'the sum of legislative and executive measures taken to increase, organize and use the national scientific and technological potential with the object of achieving the country's overall development aims and enhancing its position in the world'.

Few countries in the world today have a clearly enunciated science policy. What they have is rather an agglomerate of many partial science and technology policies, more or less loosely co-ordinated at the centre. The various dimensions of these science policies have also ranged from a primary concern with the allocation of resources or support for basic research to recognition of science and technology as the key component in socio-economic development. But with the coming of the recognition that science—as a means of understanding the natural environment—and technology—as the means of controlling and managing it—are essential to the developmental effort, many nations are now attempting to formulate conscious and systematic science and technology strategies. The nation's choice of strategies necessarily reflects its social, economic and security circumstances and objectives, and cannot be separated from its broader domestic and foreign policies. It is only in the context of such an overall developmental plan that a valid science policy can be formulated. For example, major technological developments such as the 'green revolution' can raise massive problems of economic dislocation, social unrest and political upheaval. Hence the planning of the science and technology strategies requires close inter-meshing of the science and technology system into the socio-economic system.

The starting-point for formulating a national science and technology policy has to be a statement of long-term national objectives. This statement

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will have developed, in a democracy, from a confrontation of what is considered desirable as a future national position, and what is considered achievable under the internal and external constraints. Any assessment of future possibilities and appropriate development strategies must be based on an analysis of national strengths and weaknesses. Such assessment would need to take into account the potential contribution that science and technology can offer in the development of latent resources or the more productive use of existing resources. The use of science and technology can extend the horizons and offer a wide range of options to the socio-economic planners. Of course, setting the national goals and determining the priorities within the limits of available resources are political decisions to be taken by the national leadership. It is, however, the role of the science and technology planners to ensure that these decisions are based on the fullest and most accurate knowledge available, and that the scientific and technological resources are then applied in the most effective manner possible.

Some General Characteristics of Science Policy and Planning

Within the guidelines of the overall development plan, an operational strategy as contained in a science and technology plan needs to be devised to cover the two broad functions of science policy—development of the scientific and technological potential and its effective use. Certain observations regarding the characteristics of science policies for the developing countries are in order.

Firstly, in view of the fact that most developing countries do not have the resources, either financial or of skilled man-power, to adopt a strategy of developing science and technology all across the board, it becomes imperative that they select certain fields for development. It is this selection that forms the core of a science and technology plan. Secondly, the planning of science and technology policy in the developing countries must be concerned not only with the development of scientific potential but also with the application of existing knowledge, augmented as found necessary by indigenous research or by importation, to the production of goods and services. For this it must cover the whole 'innovation chain'—research, development, and innovation through invention and diffusion. A science and technology policy which is solely concerned with research and development programmes will be of little practical value, as the translation of its results into economic uses—the dissemination, innovation and diffusion stages—is often the weakest link in the chain in the developing countries.

Another area of weakness lies in the institutional arrangements and inter-relationships developed between the universities, research centres and the productive sectors of the economy for the implementation of the policy. These should ensure not only that research and development programmes are relevant to objectives but also that successful results are followed through to practical application. Science policy thus overlaps with such fields as agricultural extension services, industrial incentives and the analysis of market requirements. This is particularly important in the developing countries, where the economic structure does not itself create a demand for research and innovation, and where the government has to create this element in the productive sector through various operational controls and incentives.

Fourthly, science policy will also need to deal explicitly with the conditions for the supply of technological inputs. For example, it would be necessary to ensure that import of technology is the most appropriate to national needs, that it is obtained on reasonable terms, and that it is absorbed in the indigenous science and technology system. The capacity to assimilate and adapt imported technology will, of course, depend on the general level of skills, the availability and distribution of skilled personnel and the existence of a developed managerial and entrepreneurial class. Science policy would thus have to concern itself with the area of education and labour, since it has to ensure that this limited resource of skilled man-power is deployed to the best advantage.

In the broadest sense science planning—indeed, all planning—is anticipatory decision making. It consists in exerting choices in situations which have not yet occurred but which are envisioned to occur, which are inter-related and inter-dependent, and which are not yet known with certainty. Planning is essentially rationalist and interventionist in its approach, for it implies that by making commitments in advance and by taking actions in the present, it will be possible to control future events to a greater degree and to orient them in the appropriate directions in order to obtain the desired results. While planning is primarily concerned with the generation, identification and evaluation of alternatives, policy making involves establishing criteria for generating, identifying and choosing among these alternatives. Anticipatory decision making may thus be considered as the building-block of science and technology planning. Five general categories of decision can be identified in the process of planning:

(i) the definition of long-term ideals and the desired future image of the system

(ii) decisions regarding the pattern of interaction with related systems and their decision areas

(iii) decisions about the institutional infrastructure of the system
(iv) determination of the scope and nature of the activities to be performed by the system
(v) decisions on the generation and allocation of all types of resources.

These decision categories are not independent, nor can they be dealt with separately and individually. They provide, however, a framework within which to order the tasks involved in planning for scientific and technological development.

Planning begins by projecting a desired future image of the science and technology system as an ideal to be approached. This has to be done with the participation of interest groups affected by planning by exposing their values and preferences to a common view of the future.

This would thus include preferred patterns of inter-dependence with other systems, indicate contributions which science and technology can make to social and economic development, describe ideal institutional structures, explore the structure of activities to be performed, and recommend the patterns of resources acquisition and allocation, and the general strategy to be followed for implementation. Obviously, the planning horizon to which perspective planning refers is the long range, but it involves the design of a future rather than the extrapolation of current trends and existing conditions, as well as the devising of a strategy for reaching this ideal stage.

An understanding of the pattern of interaction between scientific and technological system and its inter-related systems in the environment is basic to successful planning. Science policy must concern itself with attaining coherence among these interacting systems and with exploring the possibility of using indirect instruments and mechanisms for implementing science planning decisions. The implicit policies, which are consequences of decisions taken in other sectors such as economic, educational and social, need to be examined, the contradictions to be expressed and ways to be suggested of resolving them. Science policy deals with the wide range of indirect measures that are available to government to implement its science and technology policies; which measures, while primarily directed to the functioning of the economic system, for example, the Industrial Policy Resolution, pricing of capital and raw materials, industrial standards, etc., have significant implications for the exploitation of science and technology for development, and for the demand for technological innovation by the entrepreneurs.

Institutional planning refers to the organizational network through which activities are to be carried on and resources channelled, to the rules and regu-

lations which govern institutional behaviour, and to the creation and modification of organizations for implementing scientific and technological plans. The institutional infrastructure refers not only to personnel and procurement policies but also to the creation of a 'working culture'. By 'working culture' is meant the totality of administrative practices, organizational structures, and the commitment, motivation and effectiveness of the people working in these organizations.

Activity planning provides priorities and general orientations for activities to be performed by the science and technology system and proposes measures to control and regulate the import of technology. Thus the two major tasks of activities planning are, firstly, the determination of science and technology activities that should be carried out in the country and, secondly, the specification of areas and the conditions under which scientific and technological knowledge will be acquired from foreign sources.

Resource planning deals with the acquiring and distribution of resources, the defining of specific goals and aims to be achieved with the given resources, the establishing of priorities for resource allocations, and generating the data base to interpret and monitor the effectiveness of implementation. Planning agencies do not generally have a sizable portion of the total resources allocated to science and technology under their control, and hence it is necessary to include other institutions, such as private industry and research organizations, universities, government undertakings, etc., in its purview. Resource planning, therefore, would be aimed at allocating the resources of the government efficiently as well as at directing the way in which other organizations and institutions in the scientific and technological system should allocate their resources. Resource planning deals not only with financial resources but also with supply of human resources to the science and technology system.

Science and Technology Planning Process in India

In October 1971, the Government of India set up the National Committee on Science and Technology, a successor body to COST and SACC, as an apex body for advising and assisting it in all matters pertaining to the promotion of science and technology and their application to the development and security of the nation. Under its charter the NCST had a number of responsibilities but its major task was the preparation of a science and technology plan, as part of the national socio-economic plan.

To formulate the science and technology plan, the NCST adopted a combination of the sectoral approach and an overview of the totality of the

nation's scientific and technological effort. The plan was structured in terms of 24 socio-economic sectors with a view to studying each sector critically and evolving suitable programmes of research, development and design, and science and technology inputs more broadly. Work on each sector was co-ordinated by a panel of NCST members, which in turn set up a number of Planning Groups/Task Forces. The Planning Group became the basic instrument for formulating the plan.

In devising this methodology for the preparation of the science and technology plan the NCST was guided by the following considerations:

(a) The preparation of the plan should involve the *participation* of the largest number of scientists, technologists, administrators, economists, town planners, etc., so that a broad spectrum of skills is reflected and an inter-disciplinary approach is adopted even at the micro-level.

(b) The composition of Planning Groups in each of the sectors was to cover the entire *innovation chain*, i.e. it should have representation from educational institutions, research laboratories, engineering design organizations, the productive sectors of the economy and consumers.

(c) The scientists and technologists and others invited to participate in this process of planning were to function in their *individual capacity* rather than as official representatives of the agencies or organizations to which they belonged. This was designed to ensure that institutional constraints were not imposed on the scientists and technologists in the framing of the various options and strategies available to the country at the initial stages of the planning process.

(d) The science and technology plan was to take as its starting-point the *development profile for each sector* as formulated by the Task Forces and Steering Groups of the Planning Commission to ensure that the scientific and technological projects included in the plan are derived from committed development programmes.

Although the entire economy had been divided into 24 sectors for the purposes of planning, the above methodology was not followed in all the sectors. Instead, the 24 sectors were divided broadly into 3 categories, for each of which a different methodology was adopted. For those sectors where the programme is basically to be implemented by a *single agency*, for example agriculture, defence, space, aeronautics, electronics, atomic energy and meteorology, the respective NCST Panels depended primarily on the plan proposals that were formulated by the respective agencies and organizations themselves. The NCST attempted to ensure that the planning process followed

by these agencies reflected the criteria indicated above and then appraised and co-ordinated those plans by identifying and providing backward and forward linkages with the other components of the scientific, technological and economic systems of the country. *Where the sectors covered a number of different ministries, agencies, etc.*, the NCST Panels actually developed the sectoral plans in close collaboration and co-operation with the respective agencies. In *completely new areas*, where no agencies existed, like solar and geothermal energy, cryogenics, MHD power generation, Special Materials, etc., the NCST set up Special Task Forces to prepare the sectoral plan and to recommend the kind of organizational arrangement needed to implement it. In addition to the projects generated by the various Planning Groups/Special Task Forces, a number of surveys, state of the art studies, techno-economic feasibility reports, etc., were also commissioned by the NCST.

In short, the process of formulating the science and technology plan which was adopted has been both democratic and interactive. It has directly involved over 2000 scientists, technologists, economists, administrators and others, and has led to a grass-roots formulation of the scientific and technological work that the country is capable of undertaking. Furthermore, by involving individuals covering the entire innovation chain even in the definition of scientific and technological projects, it was possible to follow a systems approach in the development of the science and technology plan.

This science and technology planning exercise has been the first attempt of its kind in our country. The formulation of a science and technology plan, however, is only the first step in the effective utilization of science and technology for development. While it charts a blueprint and a map for the future, it is only in its effective implementation that its success will lie. And it is this difficult road that lies ahead.

Notable Alumni

1. Mr. Y. P. Kaushal (1955)
   General Manager
   Mukand Iron & Steel
   Bombay

2. Mr. G. C. Bansal (1955)
   Works Manager
   Hindustan Motors Ltd
   Hooghly, West Bengal

3. Mr. P. V. Krishnaiah (1955)
   Chief Industrial Engineer
   Hindustan Motors Ltd
   Hooghly, West Bengal

4. Mr. S. M. Batra (1956)
   Corporate and General Manager
   Guest Keen Williams Ltd
   Calcutta

5. Mr. S. L. Chanda (1956)
   Chief Engineer
   Hindustan Steel Construction
   Corporation Ltd
   Calcutta

6. Dr. S. Choudhury (1956)
   Paints, Planning, Supply and
   Distribution Manager, I.C.I.
   Calcutta

7. Mr. D. Ray (1956)
   Works Manager
   Reyrolle Burn
   Howrah, West Bengal

8. Mr. K. V. Krishnamurthy (1956)
   Manager, I.T.C. Ltd
   Calcutta

9. Mr. N. Narayana Swamy (1956)
   Manufacturing Manager
   International Instruments
   Private Ltd
   Bangalore

10. Mr. M. L. Gulati (1957)
    Plant Manager, I.E.L.
    Gomiah, Bihar

11. Mr. B. Kapur (1957)
    Factory Manager
    Johnston Pumps Ltd
    Panihati, West Bengal

12. Mr. K. M. Agarwal (1958)
    Production Manager,
    Sheet Metal Division
    Hindustan Motors Ltd
    Hooghly, West Bengal

13. Dr. H. N. Ghosh (1958)
    Project Director, I.B.M.
    Wapping Falls
    Hopewell Junction, U.S.A

14. Mr. A. K. Das Gupta (1958)
    Project Manager
    Mackintosh Burn Ltd
    Calcutta

15. Mr. P. Dutt (1958)
Managing Director
Pavi. Electrical Industries
Private Ltd
Calcutta

16. Mr. T. V. G. Menon (1958)
Works Manager
Asbestos Cement Ltd
Calcutta

17. Mr. S. K. Kaul (1959)
Works Manager
Orient General Industries Ltd
Calcutta

18. Mr. M. E. Visveswaran, (1959)
Deputy Director, C.M.T.I.
Bangalore

19. Mr. P. Dutta (1960)
Chief of Material Management
& Chief of Management Services
H.E.C.
Ranchi, Bihar

20. Mr. N. Nanda (1960)
Chief Production Engineer
Hindustan Motors Ltd
Hooghly, West Bengal

21. Mr. A. K. Sen (1960)
Design Manager
Garden Reach Workshops Ltd
Calcutta

22. Mr. R. K. Agarwal (1961)
Production Planning Manager
Heavy Engineering Division
Hindustan Motors Ltd
Hooghly, West Bengal

23. Mr. I. R. Sharma (1961)
Manager, Axle Plant
Hindustan Motors Ltd
Hooghly, West Bengal

24. Dr. Anil Malhotra (1961)
Member, N.C.S.T

25. Dr. Om Johari (1962)
Head of Metal Division
Illinois Institute of Technology
Research Institute
U.S.A

26. Mr. J. K. Khosla (1963)
Head, Design Division
Metal Box
Calcutta

27. Mr. R. Ashiya (1963)
Head, Telecommand Group
I.S.S.P.
Peenya Industrial Estate
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28. Mr. T. K. Sen (1964)
Production Manager
Allied Resins & Chemicals Ltd
24 Paraganas, West Bengal

29. Mr. P. O. Varma (1964)
Head, Operations
Union Carbide India Ltd
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30. Mr. S. Chakraborty (1965)
Head, Industrial Engineering
Department
Philips India Ltd
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31. Mr. P. K. Gupta (1965)
Head, Assembly
Metal Box
Calcutta

32. Mr. S. Majumder (1965)
General Manager
Steel & Allied Products Ltd
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33. Mr. G. Bhattacharya (1967)
Manager, Scientific Equipment
Department
Philips India Ltd
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34. Mr. P. Mitra (1969)
Manager, Fabric Preparation
Dunlop India Ltd
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35. Mr. D. Bhattacharya (1969)
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Toilet Products Manager
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Table I

INTAKE AND OUTTURN OF STUDENTS (1951–1975)

	1951	1955	1959	1963	1967	1971	1975
INTAKE							
(i) B.Tech. & B.Arch. courses	224	325	360	495	411	409	454
(ii) B.Sc. (Hons)	—	6	16	64	69	61	38
(iii) M.Tech., M.C.P., M.R.P. & M.Arch.	—	90	199	109	164	122	225
(iv) D.I.I.T.	—	—	—	36	51	56	40
(v) M.Sc.	—	—	—	19	52	59	82
(vi) Research scholar/Fellow	—	46	35	76	144	85	113
OUTTURN							
(i) B.Tech. & B.Arch.	—	169	303	339	375	337	279
(ii) B.Sc.	—	13	17	14	27	52	50
(iii) M.Tech., M.C.P., M.R.P., & M.Arch.	—	30	118	199	109	126	137
(iv) D.I.I.T.	—	—	5	5	50	39	39
(v) M.Sc.	—	—	—	—	45	69	68
(vi) Ph.D.	—	—	20	19	45	37	56
(vii) D.Sc.	—	—	—	—	1	1	—

Table II

GROWTH OF STUDENT AND FACULTY POPULATION (1951–1975)

	Student	Faculty
1951	224	42
1953	827	132
1958	1628	229
1963	2001	276
1968	2437	389
1973	2144	397
1975	2394	393

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