NUCLEAR INDIA

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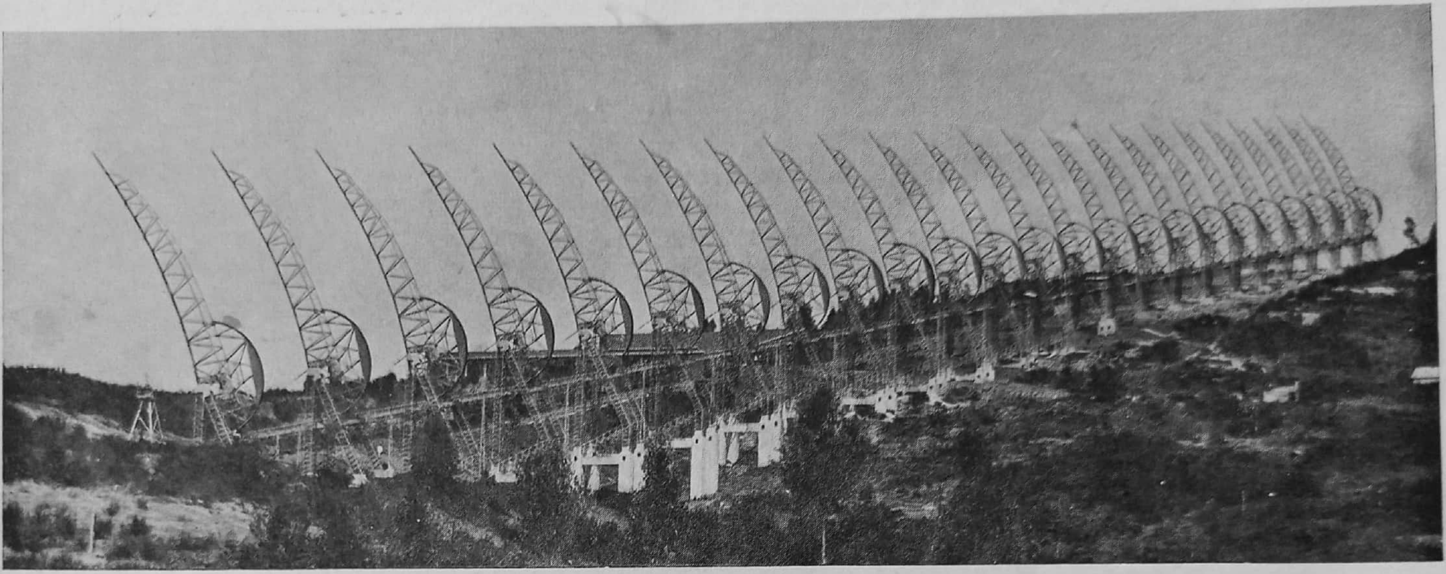

A view of the 530 m. long Ooty Radio Telescope which is located at an altitude of 2,200 metres in the Nilgiris. Each of the 24 frames is 30 m. wide. The instrument, shown pointing towards the western horizon, can be rotated in unison by 140°.

A Radio Telescope at Ootacamund

ON a hill slope close to Muthorai, a village just outside Ootacamund in the Nilgiri Hills, one of the world's largest radio telescopes is in operation.

Designed and fabricated wholly in India under the direction of Prof. G. Swarup of the Tata Institute of Fundamental Research, Bombay, the 530 m. long, 30 m. wide instrument has a novel design which takes full advantage of the location of India close to the geographic equator. A number of leading Indian engineering firms, the Mazagon Dock, the Bhabha Atomic Research Centre and the Tata Institute were associated with its fabrication and installation. There was no foreign collaboration of any kind in this project.

Three Sites

The telescope is located at an altitude of about 2,200 metres. Unlike an optical telescope, a radio telescope need not be located in the mountains at a high altitude. After an intensive search of South India, only three suitable sites with a slope equal to the latitude in the north-south direction over a length of half-kilometre could be located — and these were all in the Nilgiris. The site was finally selected in December 1965 and became available for project work in April 1966.

The whole project was executed under the auspices of the Department of Atomic Energy. Funds were made available by the Department to cover all costs on the instrument, including civil works at the site. The National Science Foundation of the United States made a generous grant of $70,000 (approx. Rs. 5.25 lakhs) to the project which was utilized for procuring a fast on-line computer which considerably enhances the sophistication of the system for programme work and analysis.

See page 4

The know-how developed as a result of work on this radio telescope falls into two categories: that relating to large antenna systems and that relating to electronics of receiver systems. Already, through this, contributions have been made to the development of microwave antenna systems needed in India.

Major Facility

The main programme that will be conducted with the instrument are: studies of radio galaxies — particularly the very distant and weak ones by the method of lunar occultation; studies of interplanetary scintillation; studies of quasars and of the recently discovered pulsating radio sources called pulsars; studies of radio emission from planets (particularly Jupiter), flare stars and the sun.

The telescope is a major national facility for research in radio astronomy — one of the frontier fields of science today. ●

New aid to astronomical research promises exciting discoveries

'Galaxy' – The High-Speed Star Gazer

As man thrusts deeper into space, astronomers, concerned not with the closer planets but with bodies that are thousands of light-years distant, are finding the answers to mysteries which in the past have been, quite literally, obscured.

The universe is built of galaxies, and galaxies are built largely of stars. An understanding of star formation is therefore necessary if we are to learn how the galaxies and the universe have evolved; and at the Royal Observatory, Edinburgh, use is now being made of a machine — the first of its kind in the world — which will provide hitherto unyielded information arising out of the search for newly-formed stars.

The machine, called the Galaxy (General Automatic Luminosity and X Y machine) was conceived and designed at the observatory and is manufactured by Faul-Coradi (Scotland) Ltd.

The invention of the Schmidt telescope more than 30 years ago provided astronomers with the means of recording information about the stars at an unprecedented rate.

Interstellar Dust

A single photograph of an area of the sky a few times larger than the area covered by the moon, taken in a few minutes on a clear, dark night by a Schmidt telescope of even moderate size, records images of tens of thousands of stars. Such photographs contain a wealth of information. Precise measurements of the positions of star images on photographs taken at different times give the angular motions of the stars, enabling their distances to be calculated. The distribution and motions of the stars which make up our galaxy can be obtained in this way.

Measurements of the strengths of the images give the brightness of the stars, and by taking photographs through different colour filters the temperatures of the stars can be deduced. Similar measurements enable the distribution of interstellar dust — the galactic fog — to be determined. This dust increasingly appears to play a crucial role in the formation of stars and the evolution of galaxies.

The task of extracting all the information from the photographs, of measuring precisely the positions and image strengths of tens of thousands of stars on each, has hitherto been beyond the capacity of available measuring devices. Because only a few hundred selected stars on each photograph could be examined, this severely restricted the research programmes of astronomers. For example, the search for newly formed stars, which are heavily obscured by clouds of interstellar dust surrounding them, has been limited to a few very small parts of our galaxy of stars.

By Prof. Hermann Bruck
Astronomer Royal for Scotland

The new Galaxy machine enables astronomers to overcome these limitations, and make full use of the information they can record at the telescope. It is now being used to measure photographs taken as part of one of the observatory's various programmes — the search for newly-formed stars almost hidden by dense obscuring clouds of interstellar dust.

Automatic measurement

In close co-operation with the Royal Observatory, Edinburgh, the design and construction of the Galaxy was embarked upon in July 1963 when a contract was placed with the Scientific Instrument Control Division of Ferranti Ltd. at Edinburgh. The requirements laid down that the precision of measurement should be one micron in the position of a star image and a quarter of a micron in the size, and that the machine should find and measure a thousand star images an hour, entirely automatically.

Four main features of the machine were decided upon: a cathode ray tube to scan the photograph with a spot of light to find the star images and measure their sizes and densities; a precise mechanical carriage to hold and position the plate with an accuracy better than a micron; a system (developed by Ferranti) for measuring the carriage position to a micron; and an electronic system similar to a computer to control the operations.

Intensive Trials

The various parts of the system were connected up and tested together for the first time in March 1969. The machine was put through a series of increasingly demanding tests, and by the end of June it had become apparent that its performance was exceeding expectations. Positions were being measured with a precision of half a micron, better by a factor of two than that demanded by the specification, and image sizes were measured with a precision 20 per cent. better than specified.

Intensive trials of the machine in the following three months showed that this performance was maintained, and the machine was formally accepted in October. By October 30, colours and brightnesses of about 40,000 stars had been measured.

To find the star images on a photograph, it is scanned by a small spot of light produced by a cathode ray tube and projected down to a chosen size, 16 microns across being typical. The light passes through the photograph and is measured by a photoelectric cell.

The passage of the spot of light over a star image is then detected by the cell as a reduction in brightness, and the position at which the event occurred is recorded. With this resolution of 16 microns, the plates currently being measured are searched at a rate of 30 square millimetres per minute

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Prof. Menon Is Seventeenth Indian FRS

PROF. M. G. K. Menon, Director of the Tata Institute of Fundamental Research, Bombay, is the seventeenth Indian to be elected Fellow of the Royal Society of London. Founded in 1660, the Royal Society occupies a unique place in the scientific world and election to it is considered a high honour by scientists.

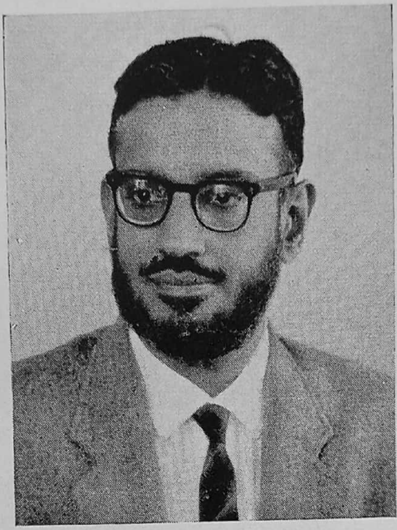
Other Indians elected to the Society are: A. Cursetji, S. Ramanujam, H. J. Bhabha, P. Maheswari, S. S. Bhatnagar, K. S. Krishnan, D. N. Wadia, M. N. Saha, S. K. Mitra, B. Sahni, C. V. Raman, S. N. Bose, P. C. Mahalanobis, C. R. Rao, T. R. Sheshadri and S. Chandrasekhar.

Prof. Menon, 42, worked with Prof. C. F. Powell, FRS at the University of Bristol, England, during the years 1949-1955. Powell was the scientist primarily responsible for developing the nuclear emulsion technique into a powerful tool capable of great precision for study of cosmic ray, elementary particle and nuclear phenomena. For these contributions, and the discovery (through observations on tracks in photographic emulsion) of the pi-meson and its decay into the mu-meson, Powell was awarded the Nobel Prize for Physics in 1950.

Neutrino Experiment

In work carried out with his colleagues at Bristol (notably Prof. C. O'Ceallaigh, M. W. Friedlander and D. Keefe), Prof. Menon contributed to development in the nuclear emulsion technique, particularly the use of stacks of stripped emulsions as large as 15 litres in volume and methods of mass determination; and through these technical developments there emerged significant results relating to the decay modes and interactions of the heavy mesons and hyperons.

Results of particular importance included the demonstration that among the charged secondary particles arising in the decays of heavy mesons there were pi-mesons, mu-mesons and electrons some arising through two-body, and others through three-body decays; that slow negative heavy mesons were much less abundant than their positive counterparts; and the first observations on the nuclear scattering of heavy mesons and its interpretations in terms of the "strangeness" concept that has just been introduced theoretically.



Prof. Menon was one of the principal spokemen of the Bristol group in those years when it was the most important research centre for work in these fields.

During 1952-1953, Professor Menon was Research Associate at the University of Bristol and, from 1953 to 1955, held the Senior Award of the Royal Commission for the Exhibition of 1851. The only other Indian to hold this Award earlier was the late Homi Bhabha.

Cosmic Ray Studies

Since 1955, he has been working at the Tata Institute of Fundamental Research in Bombay. He first concentrated, (along with V. K. Balasubramanyan, G. S. Gokhale and R. T. Redkar), in developing the technology of fabricating and flying very large balloons under tropical conditions through the very low temperatures of the equatorial tropopause. This is now a facility that enables cosmic ray work at high altitudes close to the geo-magnetic equator to be carried out in India. The significant work of the TIFR cosmic ray group on the high energy electron component, and on high energy X-ray sources are illustrative of the importance of this facility. Professor Menon's interests over the past decade have been cosmic ray studies deep underground in the Kolar Gold Fields in South India; these relate to phenomena involving high energy muons and neutrinos; this work has been carried out in collaboration with Professor S. Miyake and his group at the Osaka City University, Japan, and with Drs. V. S. Narasimham, P. V. Ramana Murthy and B. V. Sreekantan of TIFR.

Nuclear Emulsion Technique

The neutrino experiment at a depth of two and a half km. below the earth's surface involved the group under Professor A. W. Wolfendale of the Durham University, U.K. In this experiment, the first unambiguous observation was made of the interaction of a natural neutrino. These experiments illustrate the possibility of working on topics at the fore-front of scientific interest by utilizing fully the advantages that may otherwise exist — in this case the existence of very deep gold mines.

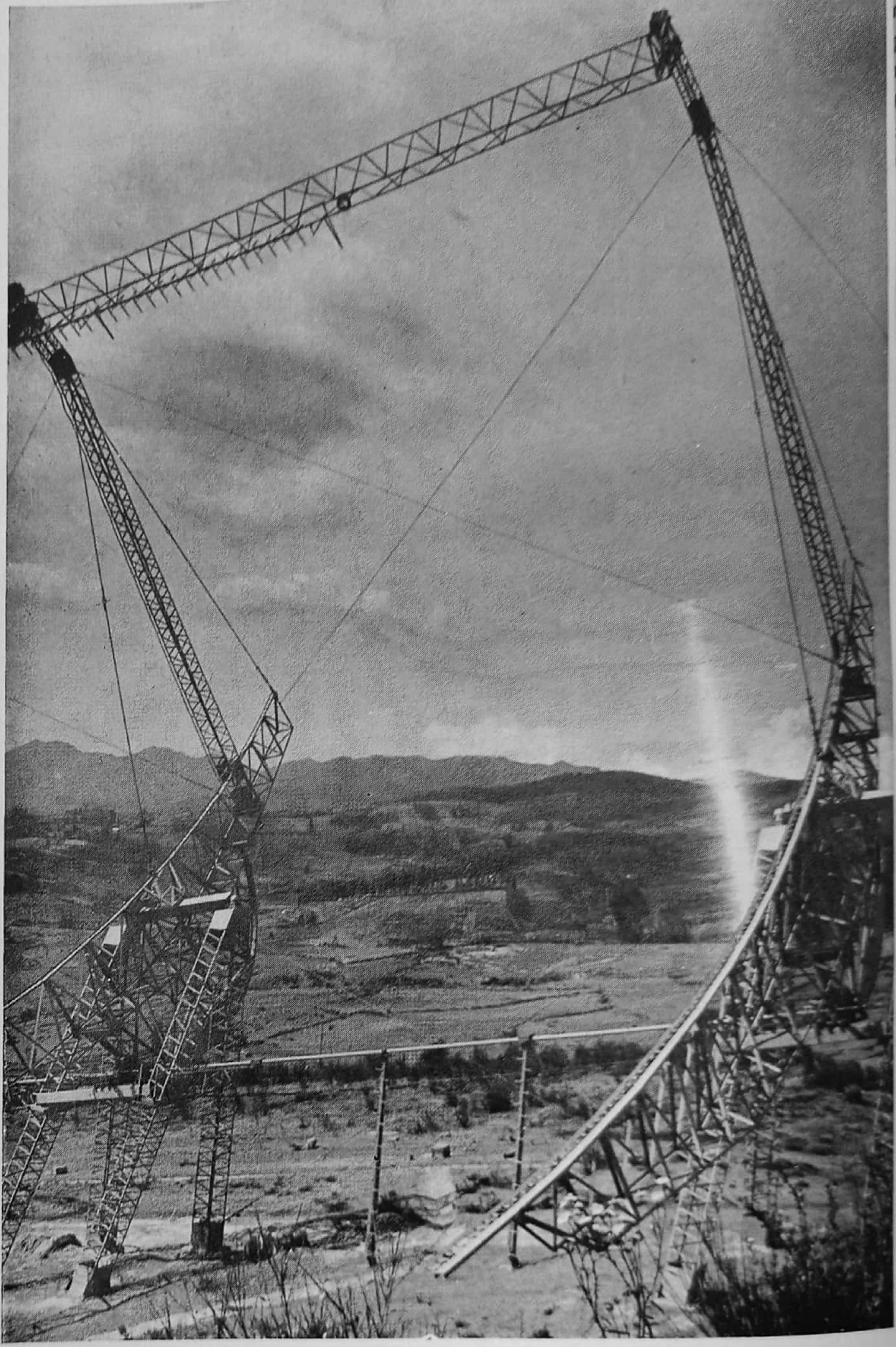
Professor Menon has also concentrated over the past decade in his capacity as Dean, Physics Faculty, Deputy Director (Physics) and as Director in the growth of programmes and groups over a wide spectrum of scientific endeavour at TIFR, which today has many outstanding scientists who have carried out work that is internationally recognized. ●

The Ooty Radio Telescope — A Major Facility

by Prof. Govind Swarup
Tata Institute of Fundamental Research

THE space age dawned with the launching of the first earth satellite in 1957. Since then, there have been a series of spectacular events, crowned by Man's landing on the moon last year. Over the same period, there have been, through studies in astronomy and astrophysics, advances concerning our knowledge of outer space that should be truly ranked as spectacular from the viewpoint of science, though by their very nature they have captured less public attention. These advances have been concerned not only with space in the immediate vicinity of the earth, but with space and the phenomena occuring in it up to the most distant reaches in the Universe that man has been able to penetrate.

Phenomena that occur in space give rise to radiations of various types; the most familiar radiations that we receive on earth are light and heat from the sun—and this arises through burn-up of the nuclei of light elements through nuclear fusion processes in the sun's interior as a result of which great quantities of energy are released. The radiations from space cover a wide range of wavelengths from the very long wavelengths characteristic of radio waves, to the very short wavelengths characteristic of the most energetic cosmic rays and gamma rays. By studying these radiations, scientists have been able to discover the nature of the phenomena that occur in space, including those that took place in the distant past.



Curved light streak shows reflection of sunlight from the fine stainless steel wires forming the reflecting surface.

New Window

Through the ages man has looked out at the Universe around him and studied it with his eyes, and with the help of instruments such as sextants and optical telescopes. In 1931, Carl Jansky discovered that there were also radiations in the radio region from outer space that he could identify as coming from specific regions such as the Milky Way. With this discovery was opened a wide new window into the Universe — that of Radio Astronomy.

A radio astronomer studies the Universe using radio waves, instead of the light waves used by the optical atronomer. Radio waves, like light waves, are electromagnetic in nature. Light from stars and galaxies generally originates from hot gases at temperatures of about 6000 to 20000°K. But radio waves arise differently. They are emitted by highly energetic particles as they move with velocities close to that of light in the presence of mag-

rontier Field

etic fields. These natural radio waves roduce a hissing type of noise when eceived by a radio telescope. With he help of a directional antenna, or radio telescope, the strength and irection of radio waves received from ifferent parts of the sky can be determined and a map of the radio sky prepared. It should be pointed out that just as there are stars which are visible, there are discrete radio sources or radio galaxies that can be 'seen' through radio waves with radio telescopes.

Studies of distant radio galaxies and quasi-stellar objects (quasars) have provided evidence of vast explosions occurring in distant parts of our Universe which give rise to highly energetic particles. It appears that powerful explosions occur in some galaxies as a result of which matter more than a million times the mass of the sun is completely converted to energy. The energy released is truly fantastic. Many theories have been propounded, but the mechanism of these violent events is little understood.

Powerful Facility

Radio Astronomy has yielded spectacular results over the past four decades of its existence. The past decade especially has seen some of the most exciting discoveries ever made through this window. These discoveries relate to quasars and pulsars, the existence of a universal microwave backround radiation, the opening up of maser astronomy with studies of the hydroxyl (OH) molecules, and evidence of the existence of molecules as complex as ammonia, water and formaldehyde in the outer reaches of space.

In India, radio astronomers have been provided a new tool for studies in this frontier field of science. At Ootacamund in the Nilgiri Hills, one of the most powerful radio telescopes in the world was commissioned in February this year. Designed and built wholly by Indian scientists and engineers under the aegis of the Tata Institute of Fundamental Research, Bombay, this advanced instrument provides Indian scientists opportunities of working at the very limits of man's endeavour in this area anywhere in the world today.

The Ooty radio telescope has a special design which utilizes the location of India near the geographic equator; this design provides for large gathering power and also sufficient steerability at a relatively low cost. The instrument has a reflecting surface which is 530 m long and 30 m wide. It is about 4 times more sensitive than the 250 ft. (approx 76.2 m) dish at Jodrell Bank, England; but it is not a general purpose instrument like the latter as it operates in a fixed radio band of 324-329 mega-hertz only. A radio telescope primarily consists of a large surface on which the radio signals coming in from outer space can be reflected and brought to a focus at a point or along a line; from the focus, the signals are carried to a receiver system where they can be recorded and analysed. The most familiar design of a radio telescope is the deep saucer-like dish, such as the dish at Jodrell Bank in England; such a dish is fully steerable and can be pointed in any appropriate direction; it can be rotated along two axes that are at right angles, and can thus follow a star or galaxy during its daily motion across the sky.

The Ooty radio telescope uses a novel design. Its surface is in the form of a parabolic cylinder — like that of a long trough with a parabolic cross-section. Such reflectors provide large sensitivity or collecting area at a relatively low cost; they have been built elsewhere in the world, but they are not steerable in the east-west direction and so they cannot be used for tracking or following radio sources for more than few seconds of time. Utilizing India's proximity to the geographic equator, we have installed a 530 m long trough type reflector with its axis in the geographic north-south direction on a slope of 11°24', this angle of inclination being equal to the latitude of the station. Thus the axis of the instrument is kept parallel to the earth's axis of rotation; this arrangement enables us to follow radio sources in the east-west direction for 9½ hours per day by a mechanical rotation of the reflector along its long axis. The beam of the radio telescope, or the direction in which it is looking, can be moved in the north-south direction by changing the lengths of interconnecting transmission lines. Thus, by mechanical rotation in the east-west direction, and by electrical phasing to obtain beam movement in the north-south direction, the telescope achieves steerability. *(See figure on page 6.)*

Prof. Govind Swarup, 41, has been with the Tata Institute of Fundamental Research since 1963. An MSc in Physics from Allahabad, Professor Swarup worked during 1950-53 and 1955-56 at the National Physical Laboratory, New Delhi. Between 1953-55 he was with the Radio Astronomy Group of the Commonwealth Scientific and Industrial Research Organisation, Sydney, Australia, working with Dr. J. L. Pawsey. Between 1956-63 Prof. Swarup worked at the Harvard University (for one year) and for six years at Stanford University where he obtained his Ph.D. in Radio Astronomy in 1961.

Parallel Wires

The telescope is located on a hill that has a slope of about 11°. On this slope there are 24 equidistant, tall steel towers; and on top of each of these is mounted a parabolic frame; the two ends of each parabolic frame are 30 m. apart. The 24 frames span

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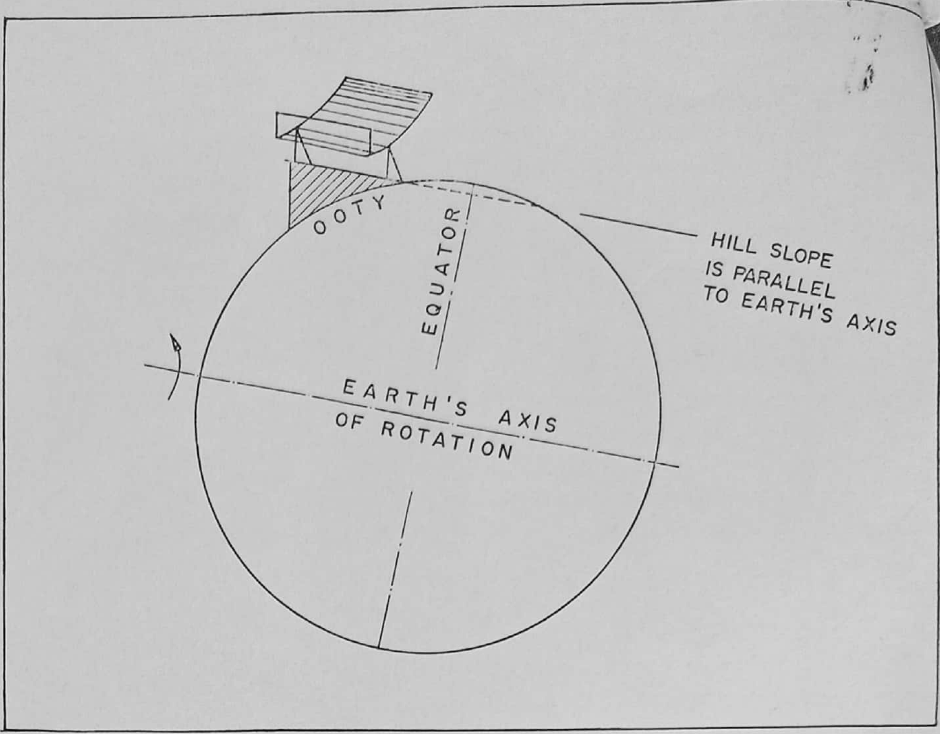
a horizontal distance of 530 m. These frames are connected together by 1100 stainless steel wires, each 530 m. long. The wires are parallel to one another and constitute the radio reflecting surface of the telescope. Radio waves incident on the surface are reflected on the 968 radio dipoles placed along the focal line of the telescope and thence carried to a multi-beam receiver providing 12 simultaneous beams in the sky. The entire 530 m x 30 m surface can be rotated in unison through an angle of about 140° using complex electrical and mechanical fixtures — all designed and fabricated in India.



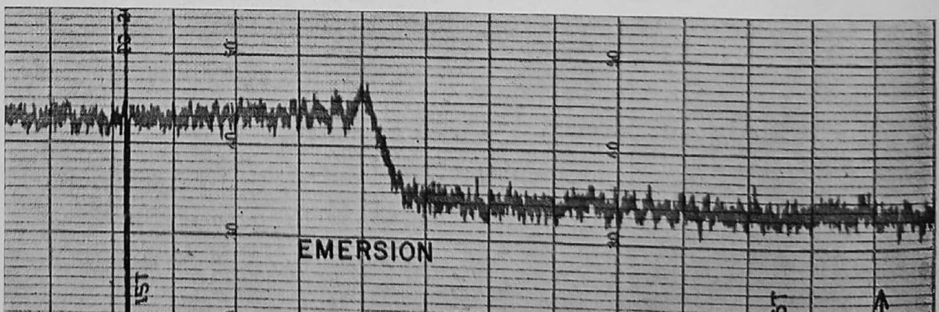
"Lunar Occultation"

The cost of a parabolic dish with the same sensitivity and steerability as the Ooty Radio Telescope is estimated to be at least 20 times higher. An array consisting of a large number of smaller size dishes would also cost very much more. But in contrast to a parabolic dish, the parabolic cylindrical reflector of the Ooty Telescope can be operated at only one or two fixed radio bands.

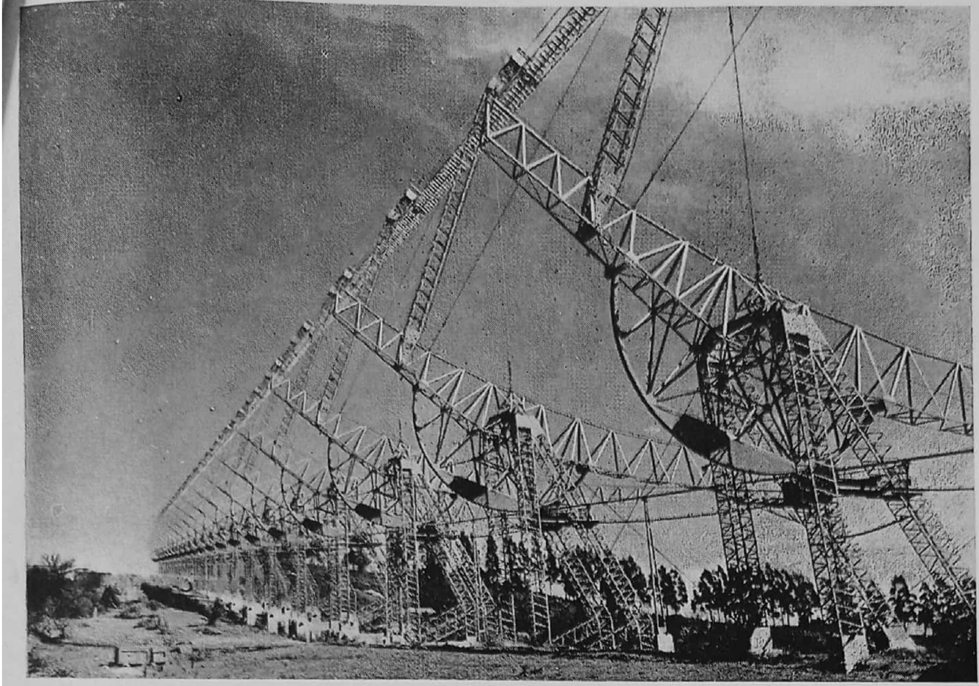
The design of the Ootacamund Radio Telescope was conceived to enable study of distant radio galaxies by the method of "lunar occultation". As the moon moves in the sky, its sharp edge eclipses radio waves from a distant radio source. A narrow source goes behind the moon's limb suddenly but a broad source disappears gradually. As the moon moves away, the source emerges again. A record of this phenomena allows a very precise pin-pointing of a radio source and also provides information about the shape of the radio source. This technique is extremely powerful and gives resolution of better than a second of arc; it has not been exploited fully so far because of the lack of a sufficiently large and steerable radio telescope in any part of the world.

New Sources

At Ooty, during the first 14 days of operation, occultation observations of 16 radio sources were made; 11 of them were objects which were catalogued by other observatories, but for which detailed structure data was not available; 5 of them have been detected by us for the first time. So far astronomers have catalogued more than 15,000 sources, but detailed structure with resolution of few seconds of arc is available for only about 30 comparatively strong sources. With the Ooty instrument we expect to observe several hundred new sources every year with resolution of about 1 second of arc. These observations will be compared with photographs taken with the 48" (approx. 1.2 m.) telescope of Mt. Palomar Observatory to find the nature of associated optical emission. It is also planned to study the same objects with the new 48" (approx. 1.2 m.) telescope at Rangapur of Osmania University, near Hyderabad and with the 40" (approx. 1 m.) telescopes being installed at the Kodaikanal and Nainital Observatories. The data will be used for studying the origin and evolution of radio galaxies. Studies of very distant and consequently weak radio galaxies lying at the edge of the



A record of lunar occultation observations of radio source 4C 22·21. Power received by the radio telescope increases as source emerges from behind the moon's limb. The rate of increase (diffraction pattern) gives information about source structure.



A close-up of the radio telescope. Radio waves reflected by a surface consisting of 1100 stainless steel wires are focussed to a long line shown at the upper end of the picture. Half circle on each tower is a 5 m dia. gear meshed to a 530 m long drive shaft.

universe is likely to be highly significant for cosmological problems relating to the nature of the universe.

It is also planned to undertake a survey of weak radio sources in the southern hemisphere and to measure the declination of some of the already catalogued radio sources by other observatories. The instrument will also be available for studies of galactic objects, studies of radio emission from planets (particularly Jupiter), flare stars and the sun. We may in addition undertake measurements of deuterium to hydrogen ratio because of the considerable astrophysical significance of the problem.

A major programme has been started for detailed studies of the recently discovered pulsating radio sources (pulsars). These sources emit pulses of radio emission with a period accurate to one part in a million. So far only 50 pulsars have been detected by radio astronomers with periods ranging from a fraction of a second to a few seconds. It is believed that pulsars are associated with highly compact neutron stars which have densities of about billion times that of the earth and which rotate roughly once a second. Our instrument at Ooty is well suited to study them in detail and perhaps also for discovering many new pulsars.

Other Telescopes

The radio telescope is being currently operated in the frequency band of 324—329 MHz. It is planned to build another dipole array and a receiver system for extending the operation of the instrument to a second frequency, around 100 MHz. A radio interferometer is being set up by locating two 13.5 m. dishes at the ends of a north-south line, 3.5 km to the west, and parallel to the axis of the radio telescope.

It would be of interest to compare the Ooty instrument with other radio telescopes in the world. The 250-ft. (approx. 76.2 m.) dish at Jodrell Bank, England, or the 210-ft. (approx. 64 m.) dish at Parkes, Australia are very valuable instruments as they focus radio waves to a point and therefore can be operated over a wide frequency range, from centimeter to meter wavelengths. But their resolution is very limited as their size is only a few hundred times to the wavelength of radio waves.

For obtaining sharp 'radio pictures' radio telescopes of special design have been constructed in several countries —for example, the one mile long (approx. 1.6 km) aperture-synthesis interferometer developed by Prof. Ryle in England or the one mile (approx. 1.6 km) crossed-antenna built by Prof. Mill in Australia. But to get resolution of about one second of arc that is achievable with moon-occultation, one would need phase-stable interferometers having a size of about 20 km. Such interferometers have not been built so far.

Jodrell Bank

The sensitivity of the Jodrell Bank dish is lower by a factor of four than that of the Ooty Radio Telescope. Therefore, the Jodrell Bank dish is not suitable for study of a large number of radio galaxies by the method of lunar occultation. The only steerable radio telescope in the world with larger sensitivity than that of the Ooty Radio Telescope is the 1000-ft (approx. 300 m) bowl in the ground at Puerto Rico, U.S.A. But it can follow the moon for only about 10 per cent of time compared to the Ooty instrument.

The Ooty radio telescope represents a major facility in a frontier area of science. It can make a significant contribution to the training of young scientists in the country, who will either be able to use it for advancing fundamental knowledge in the areas of astrophysics and astronomy, or through their training, contribute to the country's needs involving large antenna systems and associated electronics.

The late Dr. Bhabha had always envisaged that major national facilities set up in the country would be made available to institutions and workers who could make use of such facilities, but who by themselves could not set these up or utilize them fully. It is hoped that the Ooty Radio Telescope will make its contribution to the growth of astronomy and astrophysics in India. ●

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10,000 stars being found and recorded per hour.

A Closer Look

When the star images have been found, the carriage carrying the photographic plate is moved to put each star in turn beneath a scanning system working at high magnification, for a more detailed examination of each image.

The spot of light is now only one micron across, and this is scanned in a spiral pattern over the image. The amount of light passing through and around the image is again measured by a photoelectric cell. If the image is not centred on the spiral pattern, more light passes through one side than through the other, and the carriage is moved until equality is obtained. The position of the carriage is measured, and in this way the position of the image is determined in units of a micron.

Meanwhile, the measurements of the amounts of light passing through different parts of the image are being examined by the control system in order to determine the image structure. A measurement of the strength of the image is obtained in units of a quarter of a micron; this measurement is directly related to the brightness of the star photographed. The measurements of position and brightness are coded as output on computer tape, at the rate of 1,000 stars an hour, for subsequent analysis in the observatory's computer.

The most significant feature of the Galaxy machine is not so much its precision as its speed. The number of stars which can be photographed by even the moderately-sized Schmidt telescopes at the Royal Observatory, Edinburgh, is some tens of millions, and in the past when we have wanted to measure position or brightness we have been confined to a few hundreds or thousands of stars.

We had information, therefore, about only a very tiny sample of the stars in our galaxy, which contains some two hundred thousand million stars. Now, with the Galaxy machine, it is possible to measure substantial samples of the total number of stars which are detectable.

The importance of all this to astronomers is that it makes possible researches that could not be undertaken before because we were unable to collect the information required to carry them out. For instance a search of the whole Milky Way for newly-formed stars was a task beyond the capacity of existing instruments.

Essential Equipment

Over the next few years there will be an increase in the number of large telescopes available to British astronomers, and this will in turn increase the need for machines like the Galaxy. Indeed, any observatory in any part of the world which is involved in the work of measuring the position and brightness of stars will find it essential to be equipped with such a machine if it is going to be able to compete in the field of modern astronomical research.

We in Edinburgh now face a major task in programming the computer to deal with the output of the Galaxy machine, and we look forward with some excitement to the discoveries which will be made by using it to explore the galaxy of stars. *(Reprinted from "This Is Britain" March 1970)*

The Harwell Isotope Bureau—A Link With Industry

ON May 1st a new body — the Harwell Isotope Bureau — will come into existence at the Atomic Energy Research Establishment, U.K. strengthening and extending a 20-year old link with industry.

From its very beginnings Harwell has worked to develop and promote useful industrial applications for the radioisotopes produced in its nuclear reactors, but since 1960 all work in this field has been carried out at the Wantage Research Laboratory, some 16 km away. Now, as part of the process of concentrating the resources of the UKAEA, the Wantage Laboratory is being closed and its work and staff are being transferred in stages to appropriate Harwell divisions.

The Isotope Bureau is being created to ensure that there is no break in the close contacts that Wantage staff have established with industrial organisations over the last 10 years, to extend these contacts further, and to link them with the full resources of the parent establishment.

The Isotope Bureau will take over the functions of the Industrial Liaison Office at Wantage, and will act as a central point for handling incoming enquiries relating to isotope applications and radiation processing. It will actively seek to promote industrial interest in radioisotope instruments and tracer techniques and in the uses of ionizing radiations, and it will seek new ways in which Harwell's special skills and equipment can be used to the best advantage of industry and of the nation. ●

Symposium on Radiation Physics

A national symposium on Radiation Physics will be held at Trombay from November 9 to 12, 1970, under the auspices of the Bhabha Atomic Research Centre (BARC) Bombay 85. The topics to be covered are: interaction of radiation with matter; radiation transport; radiation dosimetry; environmental radioactivity; and units and standards.

Scientists wishing to participate are requested to contact Shri K. Santhanam, Secretary, National Symposium on Radiation Physics, Health Physics Division, BARC, Bombay 85.

The last date for submission of papers and abstracts is September 1.

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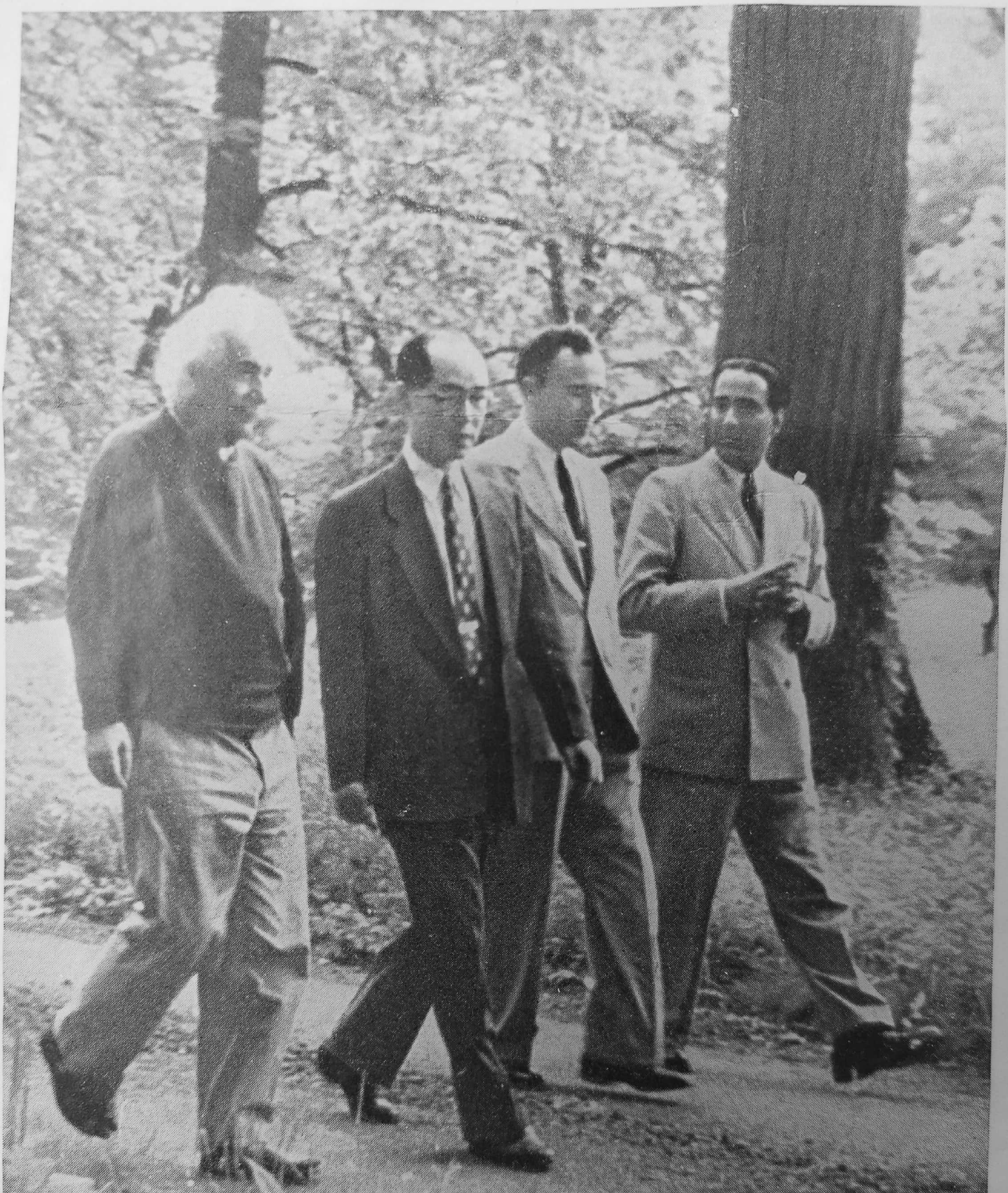
The Tata Institute of Fundamental Research was conceived as "an embryo from which I hope to build up in the course of time a school of physics comparable to the best anywhere" by the late Dr. H. J. Bhabha in a historic letter to Sir Dorab Tata Trust in March 1944 — more than a year before the Atomic Age dawned on this world. The Institute, true to his hopes, is today a recognized centre for advanced research in physics and mathematics, second to none in the world.

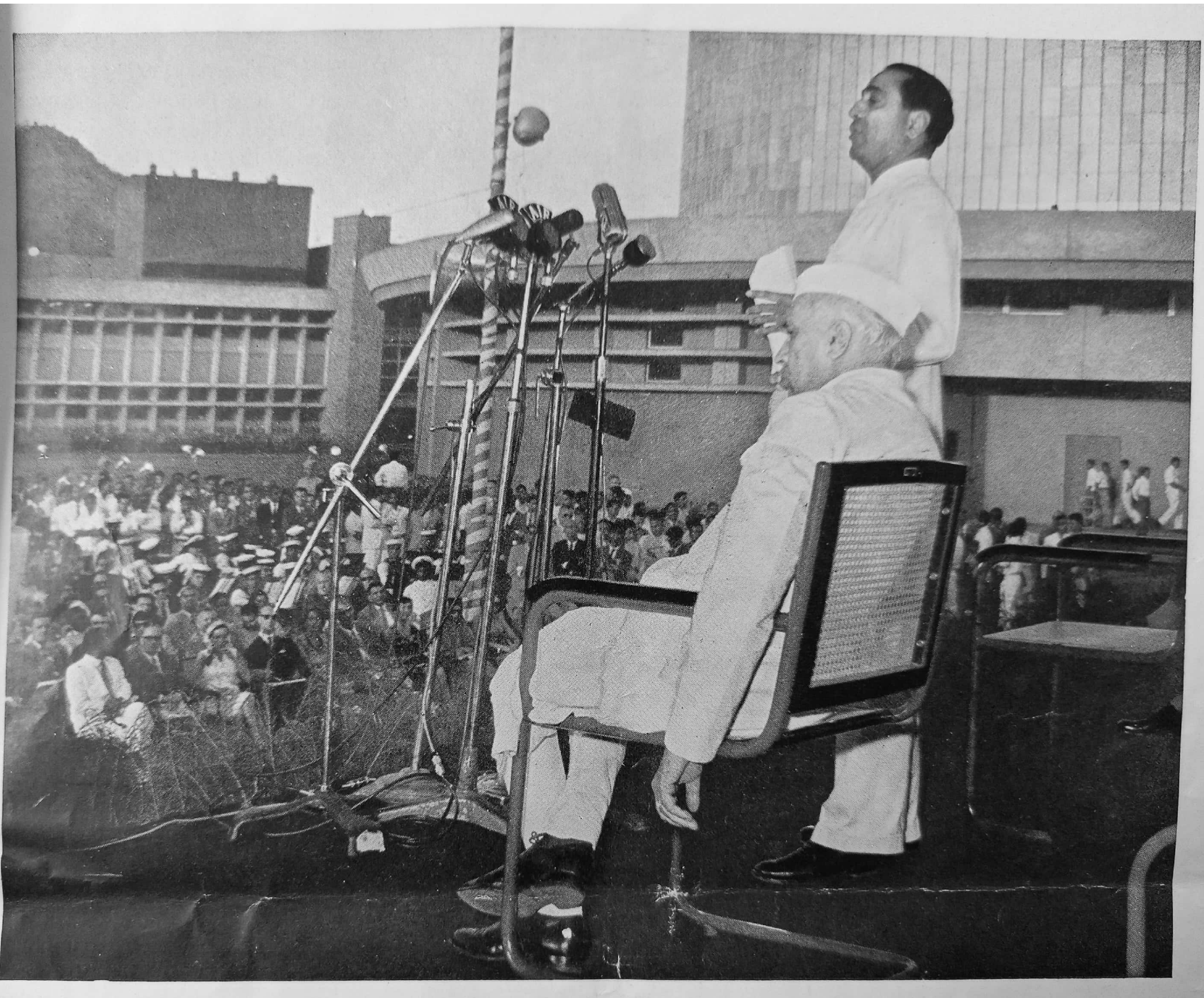
The pictures show the building of the Institute and (below) its lobby.

would give to the lowliest among us the beginnings of a decent life.

"All the gentlest and warmest thoughts of this gathering, where no eyes can remain dry, go forth to the grieving mother Meherbai and brother Jamshed and to those who were nearest to him."

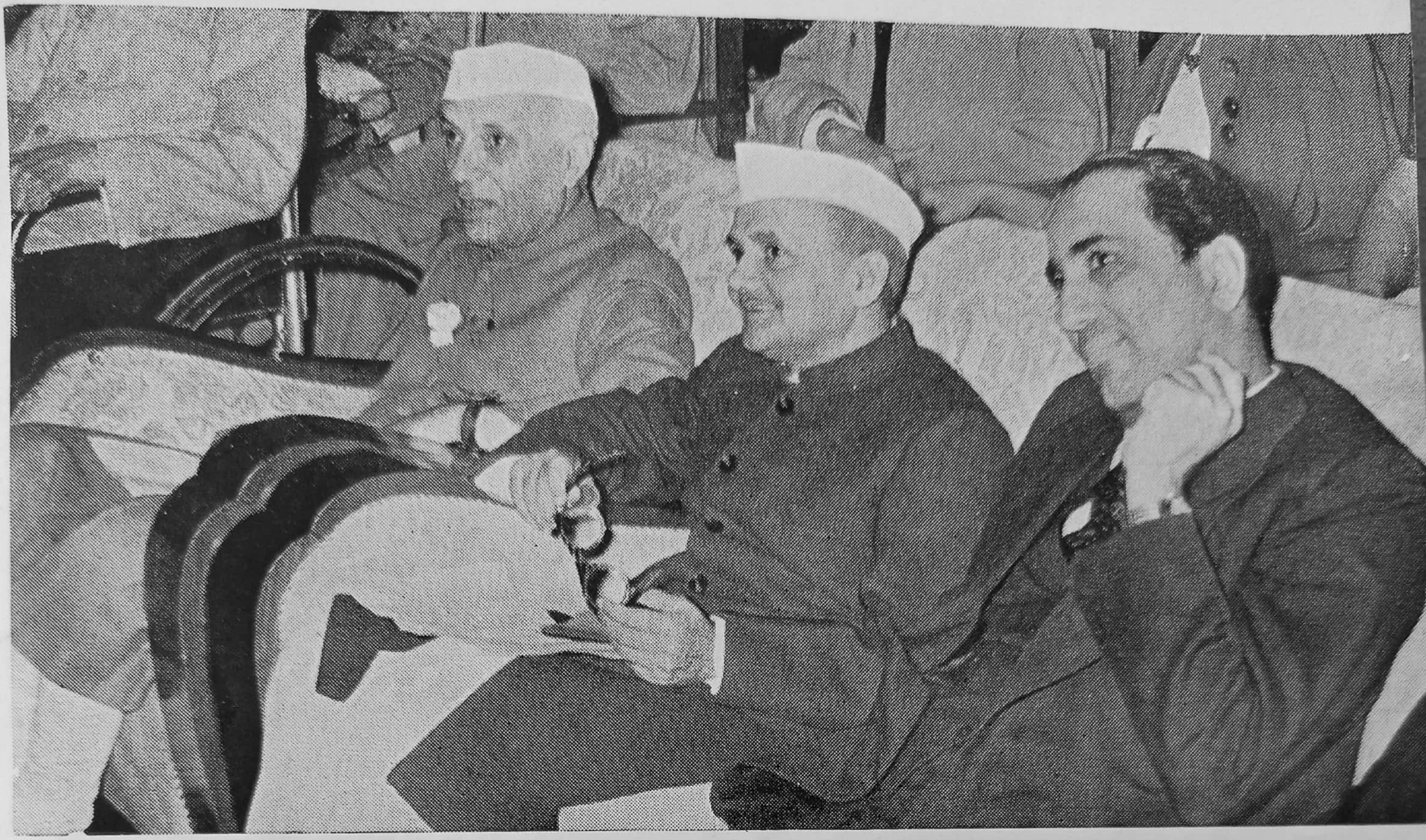


With Albert Einstein in 1947 (extreme left). Second from left is Nobel Laureate Hideki Yukawa of Japan, and next to him is Prof. John Wheeler of Princeton.



With the late Prime Minister Jawaharlal Nehru at the formal inauguration ceremony of reactor CIRUS at Trombay, January 16, 1961.

With Niels Bohr.



With former Prime Ministers Jawaharlal Nehru and Lal Bahadur Shastri.

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