various steps which have been taken to make valves increasingly reliable in operation. Dr. Thomson pointed out that valves are already completely reliable so far as home radio and television sets are concerned; at the same time, he emphasized the fact that the universal application of electronic machinery in offices, factories and in means of transport depends largely upon the reliability of electronic components.

The lecture closed with a brief speculation as to the future. While some may be of the opinion that an electronic valve or tube should never be used if it can be avoided, it is an essential item for high-speed operation. While this speed is still too low for many modern applications, it is likely that in the next half-century this speed of control will be exploited in all fields of activity.

An expression of thanks to the lecturers was made by Mr. C. W. Oatley, chairman of the Radio Section of the Institution, and by Sir Gordon Radley, vice-president of the Institution; Sir Gordon remarked that if Sir Ambrose Fleming could have been present at this jubilee celebration of his invention, he would have been thrilled by the very large family that has sprung from the original and simple diode, and the variety of parts they have played in peace and in war.

R. L. SMITH-ROSE

PHYSICAL RESEARCH LABORATORY, AHMEDABAD

By DR. K. R. RAMANATHAN

Director

A RESEARCH laboratory for the study of cosmic rays was started at Ahmedabad in 1947 by a private body called the Karmakshetra Educational Foundation. During the past seven years, with generous assistance from the Ahmedabad Education Society, the Government of Bombay, the Ministry of Scientific Research and the Atomic Energy Commission of India, the Physical Research Laboratory, as it is known, has steadily expanded and widened its scientific interests. The foundation stone of its new building was laid by Sir Chandrashekhar Venkata Raman in 1952 and the building was opened by the Prime Minister, Shri Jawahar Lal Nehru, on April 10, 1954.

The building is in the Gujarat University campus, and facing it are the laboratories of the Ahmedabad Textile Industry's Research Association (see *Nature*, Sept. 25, p. 578) and the Lalbhai Dalpatbhai College of Engineering. In a large field, west of the Laboratory, are a 72-ft. wind tower, radio masts and an experimental hut for ionospheric research. The central wing of the Laboratory runs east to west and has two floors. Nine research rooms on the first floor and five on the ground floor are accommodated in this wing. For cosmic ray measurements, one of the research rooms on the first floor has a specially constructed light roof of aluminium. A conveniently accessible terrace on the first floor is used for observational work on the sun and the sky. The central wing of the Laboratory on the ground floor connects at one end to the library and a seminar room. The staircase is situated at the western end of the central wing, where there is also an experimental area with a high ceiling. This is flanked by the workshop, the dark room, the store and a

preparation section. Adjoining the workshop is a yard and a carpentry shop.

The initial research programme of the Laboratory was decided by the interests of its principal scientific workers: Prof. Vikram Sarabhai, who started the Laboratory, is concerned with studying the time variations of cosmic rays and the light they throw on the sources of cosmic rays; the present writer is interested in problems of atmospheric physics such as atmospheric ozone and its distribution, night air-glow and problems of the ionosphere. The programme of the Laboratory at the moment comprises an integrated study of the different kinds of radiations which are received on the earth and their geophysical consequences. In order to carry out such a programme satisfactorily, two more Departments, one of Theoretical Physics and another of Radiophysics and Electronics, were added in 1949. With thirty research workers drawn from different parts of the country, the Physical Research Laboratory at Ahmedabad is now an established centre for advanced study and research in experimental and theoretical physics in western India.

Department of Atmospheric Physics. In India the Council of Scientific and Industrial Research has for many years supported a research scheme for the study of atmospheric ozone and the weather, and, with the co-operation of the India Meteorological Department, three ozone-measuring stations have been established at Delhi, Mt. Abu and Veraval. Work done in India has shown that the amount of ozone in low latitudes up to 20° N. is small and nearly constant in different seasons, and is little affected by weather. On the other hand, in European latitudes, the amount of ozone is larger and more variable from day to day. In Indian latitudes north of 20° N., during the months May–November, the amount of ozone continues to be small and steady, but increases markedly in winter. Between December and April there are large quasi-periodic increases of ozone associated with variations of high-level winds in the upper atmosphere. Studies of the vertical distribution of ozone in the atmosphere that have been made over Delhi, Mt. Abu, Poona and Kodaikanal have established that the tropical troposphere which extends to nearly ten miles above the ground contains only small quantities of ozone, but that, as one goes to higher latitudes, more and more ozone comes down to lower levels. The change from the tropical type of ozone distribution to the extra-tropical type appears to take place in the region of high-level jet streams of westerly upper winds. The study of the correlated variations of atmospheric ozone at a number of places promises to throw light on the general circulation of the atmosphere at levels not otherwise easily accessible to observation.

An important discovery has resulted from careful ozone measurements made during moonlight. It has been shown that there is a daily variation in the amount of ozone in Indian latitudes, there being an excess of ozone during the night.

Besides the work on the ozone content of the atmosphere, a large number of radiosonde ascents have been made at Ahmedabad to study the daily and the day-to-day variations of temperature and humidity in the upper atmosphere. They have considerably increased our knowledge of the upper atmosphere over north-west India, and have also been of help in interpreting the corresponding variations of cosmic ray intensities.

Physical Research Laboratory, Ahmedabad

Photo, by J. M. Shah

Studies of twilight sky intensities and polarizations have been undertaken using a photo-multiplier. Measurements on the brightness of the sky in different narrow spectral bands have been carried out at Mt. Abu from sunset to a time when full night conditions have set in. Observations show that, after the sun has gone down 5° – 6° below the horizon, there is very much more light coming from the sky than can be explained by the primary scattering of sunlight by the molecules of the upper atmosphere. Part of this is undoubtedly due to night air-glow, but there are possibly other causes, such as scattering by meteoric dust in the upper atmosphere. The problem is under investigation.

Cosmic Ray Department. Under Prof. Sarabhai, the Cosmic Ray Department has established continuous recording stations at Ahmedabad, Kodaikanal and Trivandrum. The second and third, almost at the magnetic equator, represent a mountain and a sea-level station, respectively. Observations collected over three years have shown clearly the value of directional studies with Geiger counter telescopes, with which the daily variations are larger and capable of more unambiguous interpretation than with ionization chambers.

In interpreting the experimental results, there are several factors which have to be taken into account: the atmospheric pressure, the heights of levels where cosmic-ray mesons are created, and the atmospheric temperatures near these levels. Work done at the Laboratory indicates that atmospheric mass absorption is the only important meteorological factor so far as the daily variation of the meson intensity is concerned, and its influence can be corrected for by using the known variations of atmospheric pressure. The geomagnetic effect being small, it is possible to attribute the daily variation of meson intensity, corrected for barometric pressure, to an anisotropy of the primary cosmic rays. For the daily variations of the soft electronic component and the atmospheric shower intensity there are, however, more complicated relationships with meteorological factors. These involve, besides the total mass of the air column, its vertical distribution, depending on atmospheric temperatures at different levels.

The pressure-corrected daily variation of meson intensity, which can be attributed to the anisotropy of cosmic rays, has a maximum in the forenoon at low latitudes. The dependence of this maximum on local solar time has been interpreted as indicating that the anisotropy is under solar control. This is also supported by an analysis done by Sarabhai and Kane of the published cosmic-ray data of the Carnegie Institution stations. The analysis has led to the discovery that the daily variation of the meson intensity, corrected for pressure, undergoes large changes of world-wide character, and that these changes are connected with those in solar activity. As the simplest explanation, it has therefore been suggested that a small portion of the primary cosmic radiation originates in the sun. Sarabhai and Kane have also directed attention to a geomagnetic explanation for the difference in the daily variation studied at different latitudes and with apparatus pointing to different directions.

A comprehensive programme is now in progress at the Laboratory for developing an optimum technique for the study of the anisotropy of the primary radiation.

Department of Theoretical Physics. This Department, which was first under Dr. A. B. Bhatia and is now under Dr. Vachaspati, is concerned with fundamental theory and the problems of nuclear structure. Dr. Vachaspati and his colleagues have been interested in the question of nuclear radii and have recently suggested, on the basis of electron scattering and Coulomb energy data, that the nucleus might have some negative charge at its centre along with positive charge outside. Calculations are also being done on the scattering of π -mesons by nuclei, energy-levels of μ -mesonic atoms, alpha-decay lifetimes and some aspects of field theory. The Department gives regular courses in theoretical physics to post-graduate students.

Department of Radiophysics and Electronics. Work in this Department, which is now under Dr. U. D. Desai, is directed towards the systematic recording and analysis of the characteristics of the ionosphere at Ahmedabad with an automatic multi-frequency recorder. Hourly records of reflexions of radio waves

have been obtained since February 1953, and monthly summaries of the data are published in the *Journal of Scientific and Industrial Research*. At present, Ahmedabad is one of the three stations in India at which round-the-clock observations of the ionosphere are being made.

Besides the main regions, E , F_1 and F_2 , of the ionosphere, two intermediate layers between E and F_1 have been found to be regularly recorded, and these are being studied. A comparative study is also being made of the critical frequencies and heights of F_2 reflexion at different latitudes in India, and also the effect of magnetic storms and solar flares on the F_2 region. In addition, the true heights and thicknesses of the F_1 and F_2 regions, and the total electron content in a vertical column of the atmosphere up to the height of maximum electron density, are being examined. A radio pulse transmitter, aerials and recording receiver have been built for studying winds in the ionosphere on the lines of Mitra's method.

PERMANENT MAGNET ASSOCIATION

CENTRAL RESEARCH LABORATORY

THE research activities of the Permanent Magnet Association were conducted for many years by co-operative investigations carried out in the works laboratories of its members. The technical collaboration so fostered has many advantages and such work still continues; but in 1941 centralized research, more removed from the distractions of production problems, was commenced with the equipment housed temporarily in the Physics Department of the University of Sheffield, by courtesy of the University authorities.

In 1946 it became possible to proceed with the building of the first story of a laboratory in Brown Street, Sheffield. This building, opened in 1946, gave facilities for pilot manufacture and heat treatment of magnet castings. Physical, chemical and metallographic laboratories were included, and also a workshop for apparatus and instrument construction.

The original plans have recently been completed by the addition of a second story, and on November 8 representatives of the technical Press, of local industrial concerns and of scientific establishments were invited to view the laboratories and to see some of the work now in progress. The new story includes a heat-treatment laboratory, a library and conference room and also gives additional office and storage space. These extensions, in conjunction with the e-arrangement of the older laboratories, now give a rationalized lay-out of the various sections.

The laboratory is approved by the Department of Scientific and Industrial Research but is not grant-aided, being supported wholly by the manufacturing firms who are members of the Association. The director is not only responsible for the work of the Central Laboratory, but also keeps in close touch with the research activities in the laboratories of the members, thus promoting the continuation of that technical collaboration which has been found fruitful throughout the history of the Association. In these circumstances it would be invidious to distinguish between the technical progress of the Central Research Laboratory and of the Association as a whole.

The principal activity of the Laboratory lies in the development of new permanent-magnet materials and the improvement of the properties and of the economy of processing of the existing alloys. The high energy ($BH_{\max}$) of modern magnet alloys is only obtainable by the use of large percentages of expensive metals, and so the achievement of maximum properties with minimum consumption of alloy is a constant objective. In 1945 it was possible to introduce 'Alcomax II' with average $BH_{\max}$ 4.5 megagauss-oersted and coercivity 575 oersted. Work on a wide range of additions to the basic alloy led in 1948 to the discovery of the beneficial effects of niobium in small amounts. There followed the introduction of 'Alcomax III' with $BH_{\max}$ 5.0 megagauss-oersted, coercivity 670 oersted, and of 'Alcomax IV' with $BH_{\max}$ 4.5 megagauss-oersted, coercivity 750 oersted. Shortly afterwards it was predicted on theoretical grounds that similar anisotropic alloys with a common crystal axis instead of random orientation should have markedly improved properties. Considerable experimental work led in 1952 to laboratory production of 'Columax', with remanence 13,000–14,000 gauss, $BH_{\max}$ more than 8.5 megagauss-oersted, and coercivity 750–850 oersted. The production of the structure necessary for such properties requires that the solidification of the alloy should take place progressively from one face of the casting. A mould which is chilled on one face and heated on other faces to temperatures approaching the solidus temperature of the alloy is necessary. The study of the thermal conditions for a completely columnar structure and of practical means of obtaining columnar castings is an important part of the current work. The maximum properties obtained in the laboratory cannot yet be realized in quantity production, although marked improvement on random crystal material is possible.

The metallography of 'Alcomax' alloys is not fully understood, but the diagnosis of faults in composition or heat treatment by microscopic observation of the incipient development of two-phase structures has been of practical utility. Some remarkable macroscopic structures can be seen by the polishing and etching of 'Columax' specimens, which demonstrate well the effect of crystal orientation on the reflexion of light from an etched surface.

High-energy permanent magnets of complex composition have led to secondary problems. Magnets tend to smaller and smaller sizes, and the measurement of the normal $B-H$ curve criteria on small pieces has required the development of modified apparatus and methods. New methods of chemical analysis have been necessary for alloys of increasing complexity. Electrolytic separation and the use of absorptiometric and chromatographic techniques have been found necessary. Here also the collaboration with works laboratories has been valuable, and the analytical methods standardized by the Association have been approved and published by the British Standards Institution.

With the support of the Electrical Research Association, investigations are proceeding on the stability of magnetization under extremes of temperature. Very little knowledge existed until recently on the effect of sub-zero temperatures, although there is now a definite practical interest down to -70°C . The nickel-aluminium magnet alloys are very resistant to demagnetization by heating, and so the observation in 'Alcomax' magnets of losses of magnetization to the extent of 1–4 per cent due to