environment studies, other aspects of crop physiology, such as photosynthesis of ears of cereals, and dependence of the grain : leaf ratio on radiation, have been studied. These physiology studies, in conjunction with the work of the Physics Department, should yield fundamental information of far-reaching practical consequence.

In a year in which much has been written and spoken about the harmful effects of pesticides on Nature, it is gratifying to record that several departments have devoted considerable time and effort to pesticide evaluation. Although the investigations are of widely varying character, they have all been carried out with a common purpose—"to increase the efficacy of pesticides while decreasing the risk of unwanted side-effects". The Insecticides and Fungicides Department has been concerned with the search for effective new substitutes for the more persistent organic chlorine compounds and has experimented with organo-phosphorus compounds. Initial experiments have shown that yields of wheat in a wireworm-infested field were considerably increased by applying some of these latter compounds, but further work is required to determine whether their application is a commercial proposition. In the Entomology Department, the experiment on the long-term effect of DDT and aldrin has been continued. The extent to which insecticides such as aldrin, dieldrin and DDT accumulate in worms and other soil invertebrates is being studied. Results so far indicate that the concentration of dieldrin in earthworms is several times greater than in the soil itself. Another important aspect of these investigations is the re-colonization of sterilized soil by soil invertebrates which help to maintain soil fertility.

In agricultural entomology, although much time and effort has been spent in studying pests themselves, comparatively little work has been done on their relations with the growing plant, especially on the way in which pest populations of different sizes affect the growth and yield of plants at different stages in their development. Such an investigation has been commenced at Rothamsted on both root and seed crops.

The Biochemistry Department is pursuing its interest in the extraction of leaf protein as a contribution to the improvement of protein supplies in the underdeveloped countries. Three protein-extraction units have been set up in Lincolnshire, Lucknow and Jamaica, and a pulping machine has been sent to Makerere for an investigation into the prospects of using leaf protein in Uganda. The factors which control the suitability of a crop for leaf-protein extraction are the amount of protein which accumulates in the leaf and the readiness with which it can be extracted. Maize has been found to be particularly useful, as good extraction rates are obtained over a

substantial part of the growing period, thus allowing continuity of production throughout the summer and autumn.

In the Chemistry Department, work on organic manures, soil structure and nutrient uptake has been continued. Attempts have been made to relate laboratory measurements of easily soluble nutrients to nutrient uptake in the field. Variations in such correlations in the past have been caused by variation in the structure of the same soil in different years. Ways of altering the soil structure have been tried in order to distinguish between the nutrient and physical effects of organic manures. Experiments carried out to investigate the way in which root growth and crop nutrition are influenced by soil structure have confirmed the theory that it is the rigidity of pore spaces in the soil rather than their size or continuity which affects root growth. Fertilizer placement experiments and work on nitrogen fertilizers, particularly ways of lessening losses of nitrate by leaching and denitrification, should prove to be of considerable practical significance.

The lay-out of the report, whereby the work of each department is recorded separately, often makes it difficult to deduce how much collaboration there has been between departments. The Plant Pathology report, however, includes an outstanding example of such collaboration, in the work on the cause of farmer's lung disease, which involved the Departments of Soil Microbiology, Plant Pathology and Biochemistry, and the Institute of Diseases of the Chest. Many of the problems in agriculture can only be tackled by interdepartmental co-operation, and it is hoped that the extent of such co-operation might be more clearly indicated in future.

The report contains two special reviews, on mobilization phenomena in soils and on the classic Park Grass Experiment. The character of these two reviews reflects the satisfactory blending of applied and pure scientific research conducted at Rothamsted. In his excellent review of mobilization phenomena, C. J. Bloomfield combines a summary of his own well-known work on the movement of iron in soils with a critical survey of the contributions of other workers in this field. Among the many important points he raises are the need to record the presence or absence of sulphate in investigations of the chemistry of waterlogged soils, and the difficulties involved in ferrous iron determinations in soils containing organic matter.

The report ends with a series of abstracts of papers published by the staff over the year. In all, two hundred and forty papers have been written, which is in itself a fair indication of the substantial contribution made by Rothamsted to present-day agricultural research.

D. A. MACLEOD

THE ELECTRICAL RESEARCH ASSOCIATION

THE activities of the Electrical Research Association throughout the year 1963 are recorded in the forty-third report presented to the annual general meeting held on April 29*.

Perhaps the most notable development is the building up of a substantial research programme in the electronics field. This work, which is concentrated on thin films, is directed towards helping the manufacturer of thin-film devices first by accumulating information about the production of films, the effects of impurities and the factors determining the suitability of materials for particular applications. By providing information on manufacturing techniques such as methods of deposition and on the effect of different vacuum conditions on the performance of products, and by assistance in the analysis

of faults occurring after manufacture, the Association should be able to provide much of the technical background required by industry.

Silicon monoxide, which is widely used for making insulating layers in cryatrons and microcircuits, is being investigated as its dielectric properties are known to be variable and dependent on uncontrolled deposition parameters. The evaporation of films and the investigation of their electrical properties are being carried out using an ultra-high-vacuum system in which the residual gas pressure can be reduced to 10^{-9} torr.

In relation to the deposition of thin metal films, an investigation is proceeding on the production, collimation and control of a beam of metal ions which can be directed at a suitable receiving surface. An arc discharge *in vacuo* between copper electrodes is being used to produce a high density of copper ions. It is thought that this technique will be of importance in the fabrication of thin-film

* The Electrical Research Association, 43rd Annual Report for the year ended 31st December, 1963. Pp. 92. (Leatherhead: The Electrical Research Association, 1964.)

components in which high standards of delineation and rate of deposition are necessary. Investigation of the conductivity of thin metallic films resolves naturally into that of three conduction mechanisms representing three stages in the formation of the film, namely: (1) conduction between discrete aggregates; (2) conduction between aggregates linked by metallic bridges; (3) conduction along a thin homogeneous plane parallel film. Work is in progress on all three conduction mechanisms, the last-named having already been investigated extensively.

A significant part of the Association's work on insulating materials is directed towards establishing or improving British Standards. For example, a proposed specification for capacitor tissue is nearly complete and will shortly be issued to members. A preliminary investigation is in progress on the use of non-polar plastics at a stress of about 500 kV/cm. A knowledge of the long-term effect of these high stresses and of the mechanism of failure in the absence of discharges is essential to the design of high-voltage plastic insulated cables. Theoretical work has continued on fundamental phenomena in dielectrics in the stable state and, in relation to the fundamental phenomena of instability, a paper on the theory of the stability of bubbles in insulating liquids in an electric field has been accepted for publication by the Royal Society.

Research on high-temperature plasmas has comprised further work on the magnetically constricted low-pressure d.c. arc. Probe and microwave techniques together with spectroscopic investigations have confirmed the part played by the cathode fall of potential in the production of the apparent high ion temperatures in excess of 2×10^6 K which are observed in the positive column of this low-power arc. This work has prompted a re-examination of existing theories of electrode mechanisms. The effect of electrode boundary layers and the mechanism by which current can be extracted from a flowing ionized gas constitutes one of the least understood problems of magneto-hydrodynamic power generation. A laboratory model of a novel form of plasma furnace has been built for the purpose of spheroidizing highly refractory particles.

Circuit breakers and the phenomena associated with current interruption continue to occupy an important place in the research programme. Particular attention is being directed to the further development of the 'synthetic' testing of circuit breakers. The demand for circuit breakers with still higher rupturing capacities implies increase in the size of the alternators and associated equipment of short-circuit testing stations on a scale which could be exceedingly costly. Synthetic testing which, in effect, supplies current and voltage for the test from two independent relatively low power sources, offers a possible alternative solution to the problem involving a much lower order of expenditure. While there is considerable evidence that synthetic methods can reproduce the severity of conventional testing it has still to be shown that synthetic circuits can stimulate adequately the many factors involved in the proving of circuit breakers. Among the items of research equipment developed for circuit breaker testing is a compact design of restriking voltage indicator.

The important fundamental investigation of possible binary and ternary alloys other than those of the silicon-iron binary series, which might offer improved characteristics in soft magnetic core materials, continues. This work is being carried on mainly at the British Iron and Steel Research Association Laboratories at Sheffield. In relation to transformer noise, tests are being made to ascertain what correlation exists between magnetostriction and core vibration. These are being made on transformer cores having similar magnetic properties but widely different values of magnetostriction.

An extensive investigation has been made of the over-voltages which occur in high-voltage transmission systems as a result of switching operations. A critical résumé has been prepared of the amplitudes, wave shapes and

frequency of occurrence of switching over-voltages in extra-high-voltage transmission systems. An automatic surge oscillograph has been installed on one of the 275-kV transmission lines of the British Grid which is equipped with automatically reclosing circuit breakers in order to obtain information about the over-voltages produced by high-speed reclosure. The Association's facilities for power system analysis, particularly complex transient problems, have been extended by additions to the network analyser or, as it is now termed, the 'Integrated Computer'.

Transient problems have been dealt with relating to 50-c/s a.c. railway electrification, switching surges on high-voltage d.c. submarine cables, rate of rise of restriking voltage on large-scale systems and the fault contribution from large induction motors. The analyser is no longer used for load flow and stability investigations, as computer programmes are now available for the solution of those problems on digital machines.

The rating of cables constitutes an important part of the work of the division dealing with lines and cables for power supply. A field investigation on the thermal behaviour of buried cables is being made in co-operation with various area electricity boards, the Central Electricity Generating Board and the Cable Makers Association. This investigation is concerned with the influence of soil moisture migration on the power-rating of cables buried directly in the soil and with the exploration of methods of mitigating thermal run-away due to drying out in the summer. Experiments have been made with 'backfill' materials with good thermal properties and promising results have been obtained with impermeable cover and weak mortar bedding.

One section of the programme of work on intrinsic safety has been completed by the investigation of a further nine inflammable gases, and all inflammable gases and vapours of industrial importance are now included in a British Standard Specification. Work on the relationship between circuit current and the probability of ignition has shown that the safety factor at present used ensures that the probability of ignition is as low as $1:10^6$. Investigations concerned with rotating machines comprise an investigation of unbalanced magnetic pull and the continuation of work on tooth ripple phenomena in alternators.

Among the non-industrial applications, electrical heating takes quite an important place. Various aspects of off-peak floor heating are now being investigated. Field trials of floor heating in multi-story flats have reached a stage which enables definite recommendations to be made regarding floor structure, floor and building insulation and cable spacing. A related problem, that of the static electrification of carpets, has been investigated during the year and a report issued. There is increased general interest in problems of static electrification resulting from warmer and drier atmospheric conditions in buildings, the development of certain new industrial processes and the widespread use of very readily electrified plastic materials. Means of heat storage other than floor heating are being investigated, in particular the use of the lime-water reaction.

The Association's work related to agriculture and horticulture continues to be directed towards crop conservation, equipment in livestock husbandry and controlled environment for livestock together with instrumentation and control in horticulture and the horticultural applications of heat and light. Very encouraging results have been obtained with the dairy heat pump.

Quite outside the normal range of the Association's activities, although deriving directly from earlier work on are physics, and on lightning discharge, are the contributions to astrophysics made by Dr. C. E. R. Bruce. It has been demonstrated that the types of absorption spectrum lines which have since 1877 been regarded as evidence of rapid stellar rotation often derive from discharge-generated vortices akin to ball-lightning. A theory of ball-lightning

has been developed which appears to be in accord with all known observations.

A significant trend in the financial support given to the Association is evidenced by the large increase, relative to the general subscription income, in the specific contributions by industrial groups to specially sponsored

programmes. This, to a great extent, reflects the wish of members, especially the larger ones, to exercise a greater measure of control over the application of the funds which they provide than is possible if they simply contribute to general funds through membership subscriptions.

J. GREIG

DISTRIBUTION AND MOTIONS OF OH NEAR THE GALACTIC CENTRE

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MEASUREMENTS with the Australian 210-ft. telescope have shown¹ a wide and deep absorption by OH in the radio spectrum of Sagittarius A. The absorption occurred over a region the angular extent of which was much less than that of the whole Sagittarius A source, and it appeared likely that only the 'core' component^{2,3} of the source was being absorbed. However, the original observation did not reveal the overall angular extent of the absorbing gas.

We have since observed OH absorption in other parts of the Sagittarius A complex at 1,667 Mc/s, 1,665 Mc/s and at 1,612 Mc/s, the frequency of one of the recently detected⁴ satellite lines of OH. Absorption has been detected at all longitudes between $l_{II} = 358^\circ 30'$ and $l_{II} = 2^\circ 30'$, and for latitudes between $b_{II} = +10'$ and $b_{II} = -30'$. As was found^{1,4} for the central source of Sagittarius A, only some of the components of the continuum radiation were absorbed, and the ratios of the intensities of the lines were

smaller than the theoretical values. The OH is distributed in apparently discrete clouds with characteristic velocities. An unexpected result was that the velocities of the various clouds are constant over a range of galactic longitude, in contrast with the velocity distribution deduced from 21-cm measurements of neutral hydrogen.

Observations at intervals of $10'$ arc were made at 1,665 and 1,667 Mc/s using a modified receiver with 48 channels⁵ of band-width 37 kc/s. Absorption was found at radial velocities from +160 to -200 km/s. Partially resolved minima in the profiles at a number of discrete velocities can be traced continuously over one to two degrees in longitude. An example is given in Fig. 1; contours of the 'apparent opacity', at 1,667 Mc/s, of the gas with radial velocity near -135 km/s are superimposed on a map of the continuum at 1,670 Mc/s. (The continuum measurements were made during the present survey with a wide-band section of the receiver). The apparent opacity is defined as the amplitude of the observed absorption divided by the continuum temperature in the same direction; as in general only part of the continuum radiation is absorbed, this ratio will be a lower limit to the true opacity. The gas responsible for absorption near -135 km/s extends south of the galactic plane in a band $20'$ arc wide, the opacity being appreciable between $l_{II} = 359^\circ 10'$ and $l_{II} = 0^\circ 30'$. No contours are shown for the weaker absorption outside this longitude range. The apparent opacity reaches peak values of about 0.4, corresponding to an optical depth of at least 0.5.

Clouds of similar extent are observed at a number of other velocities. At negative velocities the gas is found mainly south of the plane in the longitude range from $358^\circ 30'$ to 1° . For positive velocities the clouds are observed to lie close to the plane, in the longitude range $l_{II} = 359^\circ 50'$ to $l_{II} = 2^\circ 30'$. These clouds have dimensions of approximately 200 parsecs at the distance of the galactic centre.

Fig. 1. Contours of the 'apparent opacity' at 1,667 Mc/s of the gas with a radial velocity near -135 km/s (1964-5 co-ordinates)

Fig. 2. Absorption profile of Sagittarius A at 1,667 Mc/s, measured with a band-width of 37 kc/s. For velocities greater than +150 km/s the profile overlaps that of the 1,665 Mc/s line