partnership with the universities and professions on one hand and the various Government departments on the other, so that new knowledge may be made available as the need arises.

It is according to this concept that the Council has devised its organization and formulated principles of working. These developments in the concept of the function of a central research organization are set out for two reasons. The first is that it is not yet fully realized that, nowadays, such organizations cannot remain pre-occupied with the institutions and staff for which they are directly responsible, but must pay attention to the development of knowledge as a whole in the field with which they are concerned. The second is that, when viewed in this larger perspective, many of the detailed problems of management disappear.

At the level of management the task of a research council is to reconcile two apparently conflicting requirements. On one hand, it has to try to ensure that the new knowledge required by society through Government is forthcoming and to this end has to distribute its support of research according to its assessment of present and future needs. On the other hand, it has to devise its conditions of support as to preserve to individual workers that intellectual initiative without which creative work cannot develop. The problem for a research organization is thus to reconcile the implementation of a balanced and comprehensive research policy at the national level with the need for intellectual freedom at the level of the individual or the research team.

The solution of this dilemma is largely a matter of the scale of operation. If resources are restricted, or one thinks only in terms of individual institutions or particular organizations, the dilemma is real, and, in order to discharge its social obligations, a research organization may then be forced to have recourse to control and direction, even at the risk of inhibiting its workers in the creative thought and initiative on which its efficiency ultimately depends. But if the scale of operation is adequate the difficulty need not arise; for if support has been spread widely and with foresight, and if the central organization commands the confidence of scientists in general, then the relevant spontaneous interest can practically always be found. In other words, the solution of the dilemma lies in drawing a distinction between direction of research policy and directing individuals. It is of the essence of policy to have an object; but in relation to creative work the path to that object lies not

through prescription to individuals, but through the informed selection of projects to be supported.

The question of what is adequate scale of operation for a central research organization with comprehensive social obligations in its particular field is, therefore, of critical importance. To-day the answer can no longer be in doubt. The demand for new knowledge is such that nothing less than the national scale will suffice, for it is only on this scale that the requisite variety of research work, interests and institutions can be found to allow the necessary freedom of initiative in policy.

There are only two qualitatively different types of scientific investigation: that which is directed to increasing understanding of naturally occurring phenomena—research—and that which aims at bringing knowledge so gained to the solution of human needs—applied research or development. Even these are little more than abstractions at either extreme of the range. Between them lie every shade and combination of activity, and it is this that makes organization in science possible. No research worker is entirely divorced in interest from his fellows or indifferent either to the use that can be made of his work or to its theoretical implications. All range, to some extent, about the centre-point of their interests, provided that they are not prevented by segregation from habitual contact with workers whose interests are contiguous. It is a major task of organization to promote such interplay. Blood transfusion would be hamstrung if separated from relevant investigations in genetics or immunopathology. Research in endocrinology would be grossly handicapped but for the experience available in clinical practice. Laboratory and practical work in nutrition mutually interact. The interdependence of chemistry, biochemistry, chemical pathology and the study of human metabolic diseases is evident. There is a regrouping of disciplines, a prominent feature of which is the disappearance of the previous barriers between the laboratory and practice. It would be undesirable, on either theoretical or practical grounds, to do anything that tended to separate research aimed at the applications of knowledge from the investigation of natural phenomena out of which this knowledge grows.

The remainder of this valuable survey into the role of a research council examines the Medical Research Council's relationship to Government. Its significance as a court of appeal in various aspects of medicine is but one tribute to its well-recognized independence.

THE ELECTRICAL RESEARCH ASSOCIATION 1961

IT is significant that the opening paragraph of the report for 1961 of the Electrical Research Association* is headed "Electronics". The paragraph records a decision of the Council to expand the activities of the Association in the electronics field.

When the Association was formed in 1920 the part played by electronics in the electrical industry had scarcely become appreciable. Developments were just beginning whereby telecommunication in all its forms was to be revolutionized and, at a later stage, profound changes were to be effected in many branches of heavy electrical engineering.

The research effort of the Association has been directed primarily towards problems in the heavy current field, but there has been a natural development of interest and activity in the many incidental applications of electronics. It is estimated that about 12 per cent of the Association's present research activities is of direct interest to the electronics branch of the industry and a further 6 per cent of indirect interest. Having regard to the central position which electronics is assuming in the electrical industry as a whole, it is now considered that the research programmes devoted to electronics and related subjects should be expanded until they reach half the total. The Council of the Association therefore proposes to examine the probable response from

* Electrical Research Association. 41st Annual Report for the year ended 31st December, 1961. Pp. 104. (E.R.A./T. 476.) (Leatherhead: Electrical Research Association, 1962.)

industry to the development of a programme much more biased towards the electronics side.

Results obtained during the past year are summarized in the Director's Report on research work under six divisional headings. Division 1, that of insulating materials, reports the continuation of the Association's work on solid and on liquid dielectrics both in the laboratories at Leatherhead and in the University Laboratories at Liverpool, Birmingham and London. The Leatherhead Laboratories are now equipped to make dielectric measurements in inert atmospheres at pressures up to 20 atmospheres and temperatures to 500° C. Work on the high-permittivity 'Skanavi' materials has shown these substances to possess two phases, at least one of which is a ferro-electric with an extremely low coercive force.

In an attempt to locate minute leakage paths through paper capacitor tissue a new technique has been devised in which the leakage current electrolyses a thin evaporated aluminium electrode. Small areas of exceptional current density can be detected in this way. The deposition of very thin films of dielectric polymers from the monomer vapour under the action of a high-frequency discharge has been successfully effected. In the field of theoretical physics work on semi-conductors has produced an interesting and potentially important result, namely, that in semiconductors with very low mobility the so-called 'band model' becomes invalid. It has been shown that the band model is valid for mobilities down to the order of $1 \text{ cm}^2 \text{ sec}^{-1} \text{ V}^{-1}$.

Under Division 2, "Power Plant", it is reported that the new laboratory for the investigation of the creep behaviour of steels is now in full operation. The programme of work which is proceeding includes long-time rupture tests on pipes and superheater tubes, creep and rupture properties of castings for turbine casings and of forgings for turbine rotors, also of steels for turbine blades. The experimental work on the properties of steam is now being extended along the 400° C and 600° C isotherms to a pressure of 9,000 lb./in.², the results available up to 5,800 lb./in.² and 750° C having been reported during the year.

Of particular interest is a group of experiments designed to obtain data required in the investigation of some of the proposed new methods of energy conversion, namely, thermonuclear fusion, magnetohydrodynamic generation and thermionic emission. Detailed information is required on the electrical conductivity, the thermal conductivity and the distribution of energy as among electrons, ions and atoms in differing forms of high-temperature plasma. A preliminary study has been made of discharge 'temperature' and of departures from the thermal equilibrium in arc discharges under a variety of conditions. Currents up to 200 amp. d.c. and 1,000 amp. peak pulse have been used in various gases at pressures from atmospheric down to 10^{-7} atmosphere and subjected to magnetic fields up to 1,000 gauss. It has been found that spectroscopic measurements of temperature may be misleading if the precise behaviour of the discharge is not taken into account.

Division 3 deals with switchgear, transformers and power system behaviour. An interesting study of the so-called anomalous loss in iron undergoing alternating magnetization has been made at the laboratories of the British Iron and Steel Research Association on behalf of the Electrical Research Association. The problem has been examined theoretically on the basis

of domain concepts, and it has been shown that for strip thicknesses down to 0.01 in. calculation predicts satisfactorily the total eddy current loss. Calculation on a classical basis may give results differing from the measured eddy loss by as much as 30 per cent of the total loss. With thinner sheets there is still an anomaly, and the hypothesis that this may be due to the locking of domain boundaries by imperfections is being examined.

It has been found in practice in the impulse testing of transformers that an impulse applied to one winding could induce in other windings voltages much higher than would be expected. This phenomenon has been demonstrated on a model and has been examined on a large production transformer by exploration with a capacitance probe.

Lines and cables for power supply comprise the field of Division 4. The rating of cables and allied problems have again attracted a good deal of attention. Methods of calculation are being reviewed as a contribution towards a programme for the international standardization of the calculation of cable ratings. Experimental work has continued on the short-circuit ratings of a range of paper-insulated, mineral-insulated and polyvinyl chloride-insulated cables.

A good deal of the effort of Division 5, "Non-industrial Applications," has been devoted to off-peak floor heating. Direct observations have been made on the relations between the constructional features of buildings and the temperature distribution with time throughout heated floors, and these have been accompanied by studies made on the Electrical Research Association's network analyser involving a wider range of parameters. These laboratory experiments are being supplemented by records obtained from occupied flats. Several floors in two new blocks of flats in the London area have been modified in accordance with the Association's recommendations and have been fully instrumented for the measurement of heat-flow and temperature distribution.

A related problem, that of the prevention of ice formation on limited areas of road surface, is being studied on the installation at the Mound, Edinburgh. Recordings are being made of the temperature distribution and heat transfer produced under a wide range of weather conditions by the heating mat.

Reductions have been made fairly recently in the bulb sizes of certain electric lamps. As a result, for a given wattage, higher temperatures are encountered, and a preliminary investigation has shown the need for modifications in lampholders and fittings. It has been represented to the British Standards Institution by the Electrical Research Association that there is an urgent need for the production of a standard lampholder of insulating material capable of withstanding the temperatures which are now attained.

In the same section are recorded the Association's activities concerned with rural electrification, farming and horticulture. In collaboration with the National Institute for Research in Dairying laboratory tests have been carried out on a dairy heat-pump, and the plant has now been installed on a farm for trial under practical conditions. A preliminary study has also been made of the application of the heat-pump principle to bulk milk-tanks on farms.

Division 6 of the report deals with industrial applications. Work on flameproof enclosures has continued and it is noted that, for the Ministry of Aviation, a determination of safe gaps for $\frac{1}{4}$ -in. and $\frac{1}{8}$ -in. flanges has been made for propane as represen-

tative of petroleum spirit. Research in the related subject of the intrinsic safety of electric circuits in explosive atmospheres has comprised, along with the extension of the range of gases studied, an investigation of the incandivory of propane-air mixtures for break sparks produced in circuits of low voltage, 0.5–2 V. It is found in such circuits that the ignition energy comes almost wholly from the stored inductive energy, that contributed directly from the supply being negligible.

Work on material transfer in welding arcs has concerned both the stable small droplet, the large globule and the transition region. The possibilities of enforced transfer by electrical means are being investigated for aluminium and for some related materials. The investigation of the long-term stability of fixed resistors under various conditions of operation or of storage continues. The present work is concentrated on standard size metal oxide film and evaporated nichrome film resistors together with miniature oxide film resistors. The behaviour of fuses is being re-

examined both experimentally and theoretically in respect of the effect of the pre-heating of the fuse.

An investigation started during the year aims at the collection of data on the occurrence of short-duration transients in low-voltage distribution systems. Such transients are known to cause damage to electronic apparatus and the immediate purpose of the investigation is to collect information as to the frequency of occurrence and the amplitude-level of these disturbances. Preliminary results indicate that pulses of the order of 50 V amplitude happen frequently, but those of 400 V or more only occasionally.

The text of the Director's report concludes with paragraphs on member relations and on the information bureau and library. Then follows a complete list of the research reports issued during the year and of published technical contributions. The structure and composition of the Divisional and Research Advisory Committees are set out in full and—a particularly valuable feature—the scope of each is briefly stated.

J. GREIG

SOLID-STATE PHYSICS

A PLEASANTLY informal meeting on several aspects of solid-state physics took place in the pure physics division of the Canadian National Research Council at Ottawa. The meeting occurred during the week of June 18–22. The main purpose was to bring experimentalists and theorists together in an informal atmosphere so that an uninhibited exchange of views and ideas could ensue. Three main areas were explored; electron transport in metals, anharmonic effects in crystals, and basic problems in metallurgy.

The discussions on electron transport theory were opened by Dr. M. Bailyn (Northwestern University, Evanston, Illinois), who outlined a new variational method that could be useful in magneto-resistance problems. This was followed by a discussion between Dr. J. Ziman (University of Cambridge) and himself on the difficulties of obtaining reliable numerical values for low-temperature transport coefficients. From this exchange of views it was evident that both the shape of the Fermi surface and of the phonon spectrum will have to be taken into account before any 'reliable numbers' can be produced from the theory. Dr. Ziman also gave an account of some of the recent developments in the theory of liquid metals. He pointed out that there is a striking correlation between the values of the electron-phonon coupling constant obtained from the resistance of liquid metals, and the transition temperatures of superconductors. Dr. G. Chester (University of Birmingham) opened a discussion on the physical interpretation of the present-day theory of superconductivity. Dr. D. K. C. MacDonald (National Research Council of Canada) raised the question as to whether there is any theoretical upper limit to superconducting transition temperatures T_c . The only theoretical answer that was forthcoming was that if the transition was mediated by electron-phonon interactions then T_c will always be very much less than the Debye temperature. Otherwise, no sound theoretical limit could be given.

Dr. Barron introduced the topic of anharmonic effects in crystals. He pointed out that from the point of view of statistical mechanics it is possible

to include some part of the anharmonic effects by redefining the phonon frequencies. This idea raises the interesting question as to how far it is possible to carry through this idea of introducing 'effective phonons' to account for anharmonic effects. In other words, to what extent can we talk in terms of effective (or re-normalized) phonons in crystals in the same way as we talk of effective (or quasi) particles in a fermion system? This question has not yet been fully explored theoretically.

Prof. F. R. N. Nabarro (University of the Witwatersrand) reviewed the properties of dislocations and discussed the present state of theories of deformation and strain hardening of crystals. It was concluded that further experimental work is required to determine the relative importance of the various possible obstacles to dislocation motion, namely: (1) the long-range stresses due to groups of dislocations piled-up on the primary slip plane; (2) the stresses due to forest dislocations on intersecting slip planes; (3) the resistance to motion of the jogs on dislocations. The danger of relying too much on observations of surface effects was emphasized. Stereo-pictures shown by Dr. Z. S. Basinski (University of Ottawa) illustrated convincingly the three-dimensional complexity of the dislocation arrangements observed by electron microscopy. Results showing the variation of stacking fault energy with composition in a number of alloy systems were presented by Dr. A. Howie (University of Cambridge) and the relation of this quantity to the mechanical properties and electronic structure of crystals was discussed.

One of the major problems in present-day physics is that of communicating effectively between different groups of physicists. A meeting such as this can provide exactly the right atmosphere to break down the 'language barrier' between experimentalists and theorists. The efforts of Dr. D. K. C. MacDonald and Dr. J. S. Dugdale (University of Ottawa) in organizing the meeting were greatly appreciated by the visitors, all of whom appeared to enjoy both the meeting and their visit to Ottawa.

G. V. CHESTER
A. HOWIE