expressed by a different Nutting term. The exponents of successive terms may or may not then differ by unity; for, with completely unrelated constituents, there may be no such simple relationship. Mr. Graham suggested that the future of rheology is very much bound up with a reconciliation of these two complementary points of view.

The last paper at the symposium, by Dr. P. Feltham, was on "The Derivation of the Nutting Equation". He gave an account of the significance of the equation, which he wrote in the form:

$$\varphi = \varepsilon^{-1}\,\sigma^{n}t^{k},$$

in which ε is strain, σ is stress, t is time and φ, n and k are temperature-dependent constants. For relaxation of stress at constant strain, this may be written: $\sigma/\sigma_0 = (t/t_0)^{-k/n}$. The equation in this form corresponds to a spectrum of Maxwellian relation times which approximates, over a wide range, to a Gaussian distribution of $\ln \tau$, originally proposed by Wiechert[8] and confirmed for certain polymers by Jenckel and Klein[10].

Dr. Feltham's own relaxation experiments[11] on polymethylmethacrylate at 80° C. showed the power law to hold up to about 200 sec.—that is, the range of relaxation times found by Jenckel and Klein corresponds fairly accurately with the true distribution. The distribution of values for the constant n, as given in the literature, is striking. For a great variety of solids, values of n tend to cluster around 1·0, 1·7 and 4·0. This clustering follows from the fact that the creep-law, $\varepsilon = A\sinh(\sigma/\sigma_c)\,t^{k}$ (where A and σ_c are temperature-dependent constants), predicted by rate process theory, is adequately approximated by Nutting's equation if $\sinh \sigma/\sigma_c$ is replaced by $(\sigma/\sigma_c)^{n}$ for the appropriate ranges of σ/σ_c and values of n.

The symposium was very well attended, and a number of speakers took part in the discussion. Dr. Treloar asked Dr. Feltham whether he had an *a priori* preference for Wiechert's Gaussian distribution rather than for the Nutting equation, to which Dr. Feltham said that he had no such preference. A speaker pointed out that often several different equations fit data almost equally well, and Dr. Scott Blair replied that, in such cases, one prefers the treatment requiring the lesser number of disposable parameters. Mr. Graham, when asked whether he felt that a synthesis between the analytical and integrative approaches is in sight, replied that, while he is optimistic, it is still too early to say; but the integrative fractional differential equations (which may be expressed as integral equations) correspond to an infinity of simultaneous equations the terms of which may perhaps represent a massed dashpot–spring (analytical) type of behaviour. The sense of the meeting seemed to be that, while nothing strikingly new had been disclosed, the symposium had provided a valuable opportunity for an exchange of views.

G. W. Scott Blair

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SCIENCE MASTERS' ASSOCIATION

ANNUAL MEETING AT OXFORD

About eight hundred teachers of science, including some from Holland, the West Indies and many parts of Africa, met in Oxford over the New Year period at the annual meeting of the Science Masters' Association.

The meeting opened with the presidential address delivered by Sir Cyril Hinshelwood to an audience which packed the Milner Hall of Rhodes House. Taking as his title "Thoughts on the Evolution of a Scientific Problem", Sir Cyril traced the variations in the way of approaching those problems of chemistry to which he had been devoting his time since the first meeting of the Association in Oxford in 1921. First there was, by intuition, a broad picture. Then followed increasing complexity as the secondary aspects were investigated, and finally the simplification and generalization. It was, as it were, first a large-scale map of a wide area, followed by highly detailed insets of minute portions of the ground, and finally, by the synthesis of the large- and the small-scale plans, a complete comprehension of the whole field. But while it seemed that the early days of any study contained much that in later times would be outworn, it was in the condensing and summarizing of that which was no longer in debate that the superiority of our scientific discipline lay. Our quest is self-destructive and self-regenerating, and the quest rather than the goal is the more important. This will be a means of training balanced judgment and of inculcating respect for the subtleties and qualitative distinctions which a study of the humanities is more usually said to afford. In the face of the task of teaching a great living and growing subject, we cannot escape the requirement that the approach must be both extensive and intensive at the same time. While the art of writing formal essays on set subjects is an elegant accomplishment, not to be despised, it is a very different art from that of precise and vivid scientific writing wherein the criteria of criticism are much more severe. If out of this kind of training there emerge men who can use not only their minds and exercise a supple judgment, but also their hands, then in Sir Cyril's opinion we need not fear that science will fail to hold its own as one of the major roads to a liberal education.

A number of lectures were given during the meeting by members of the scientific departments in Oxford. Dr. W. O. James discussed the conclusions to be drawn from recent research on the effect of oxygen upon the metabolism of plants. Dr. N. Tinbergen gave a much-appreciated lecture upon "Animal Language", in which he showed how calls, movements, colours, scents, etc., often serve to release appropriate responses in fellow members of the same species. Thus grayling butterflies have a complicated courtship of their own: having pursued the female in flight and driven her to land, the male alights and performs a low bow, and then brings her antennæ into contact with the scent organs on his front wing. Snails, in which courtship is necessarily a 'slow business', perform a love dance for one another. From such evidence it is deduced that many animals have special organs the sole function of which is the production of 'signal codes' or language. Dr. B. M. Hobby discussed the food habits of predacious insects

and suggested observational and experimental work which could be carried out in schools both for the stimulation of interest among the pupils and also for the advancement of science.

Dr. H. M. Irving discussed the differences between the analytical chemist and the chemist doing research, between the technician and the scientist, between those who know and can follow well-known techniques and those who can devise new processes and new approaches to problems new and old. In a brilliant lecture he showed the need for both kinds of worker in order that chemistry may be expanded and consolidated.

F. M. Brewer pleaded for a return to the study of inorganic chemistry—to the study of 'change' as opposed to the present emphasis upon the investigation of the properties of substances. To illustrate this, he considered the 'neglected' elements of the present-day school and university syllabuses. This neglect is mainly historical, though accessibility and ease of extraction of the ore and not over-all abundance may be the determining factor. The size of an atom and its relation to the packing within the crystalline structure of the ore are major factors in ease of extraction ; but where, as sometimes happens, plant catalytic metabolism has resulted in the condensation of a suitable compound, the extraction of the element can be achieved easily, as, for example, vanadium. To illustrate his lecture, Mr. Brewer made samples of such elements as germanium, cæsium, etc., on the lecture bench.

Dr. W. P. Grove, of the Radiochemical Centre at Amersham, in discussing the use of radioactive substances for school experiments, went very thoroughly into the hazards involved and showed that with the quantities which would be available for and could be used in schools, no danger need be contemplated ; while the other possible deterrent, the cost, is being overcome by the Radiochemical Centre, which has produced a relatively cheap detector, most of the component parts of which are already available in all well-equipped school laboratories. The Centre has nearly four hundred radioactive substances available, of which about a hundred are carbon compounds. As radioactive substances are of great use in studying solubilities, rates of absorption, analyses and many biological problems, Dr. Grove hoped that the Association would set up a committee to report on the whole subject and devise experiments suitable for schools, while he on his part would see that material was made available, with the necessary safeguards.

Lectures were also given by Dr. R. Barer on modern developments in microscopy, by Dr. N. Kurti on low-temperature research, and by Dr. H. M. Powell on the forces set up in crystals due to the electronic and electrical structure of matter.

The display of experiments and teaching aids by members of the Association was up to its usual standard. It included many ingenious devices, from the use of cooking utensils in pneumatic chemistry to cathode ray tubes and 3 *D* demonstrations with home-made apparatus. To this display by amateurs was added a professional one by the Scientific Department of the National Coal Board, showing apparatus and experiments used in the research and routine laboratories of the Board which were adaptations of normal sixth-form experiments translated into the industrial field.

By the invitation of Lord Cherwell, Sir Cyril Hinshelwood and other senior members of the Science and Medical Faculties, the Clarendon, the Physical Chemical Laboratory and other similar departments were thrown open for inspection, and members of the Association had the opportunity of discussing problems of technique, research and their pupils' welfare with a very large number of the staffs of these laboratories. Opportunity was also taken to visit institutions in Oxford and the neighbourhood, including the Atomic Energy Research Establishment at Harwell. The usual trades exhibitions were available to the members and were much appreciated.

The Mayor of Oxford accorded the Association a civic welcome in the Town Hall, and a New Year's Eve party was given by the Science and Medical Faculties of the University with the co-operation of many of the Colleges. The latter event in its setting and its charm might have come straight out of the eighteenth century.

At this meeting, the Association launched its report on "Secondary Modern School Teaching", and also reported the results of its inquiry into the exact state of the shortage of science teachers.

W. G. Rhodes

RADIO RESEARCH BOARD

REPORT FOR 1952

THE report of the Radio Research Board for 1952, which has lately been published*, follows the lines of those of previous years, the major portion of the space being taken up with the report of the director of radio research, Dr. R. L. Smith-Rose. The research undertaken is of a fundamental and, for the most part, long-term nature and, except for some problems investigated in connexion with certain developments for national defence, is made freely available. The major part of the research programme is concerned with wave propagation, as the efficient operation of any radio system depends on understanding the effects and properties of the medium between transmitting and receiving aerials ; but other work is concerned with radio noise, the electrical properties of certain materials, and techniques of power and field-strength measurements.

The work as a whole is centred at the Radio Research Station, Slough, with some items still being conducted at the National Physical Laboratory, Teddington, until further accommodation can be provided at Slough. Working in liaison with Slough on ionospheric observation, which is one of the principal lines of research undertaken, are six other radio observatories, namely, Inverness in Scotland, Port Stanley in the Falkland Islands, Singapore, Ibadan, Khartoum (operated by the University College there) and Port Lockroy in Antarctica (operated by staff from the Falkland Islands) ; the last two were established during the year under review. In addition, special projects are undertaken on behalf of the Board by university staff at the Cavendish Laboratory, Cambridge, University College, London, the Imperial College of Science and Technology, London, and University College, Swansea.

The first of the eight sections which form the director's report deals with the propagation of low-

* Department of Scientific and Industrial Research. Report of the Radio Research Board with the Report of the Director of Radio Research for the Year 1952. Pp. iv+51. (London : H.M.S.O., 1953.) 2*s*. net.