

and Urea", presented analytical data on the products of this complex polymerization. In the last paper presented, R. W. Lenz and W. K. Carrington (Dow Chemical) discussed "The Preparation of Phenylene Sulphide Polymers by the Macallum Polymerization". The reaction of *p*-dichlorobenzene with sulphur and

sodium carbonate at 300–350° to give a high molecular weight phenylene sulphide polymer probably proceeds partly by a direct attack of sulphur diradicals on the dihalide and partly by attack of sodium sulphide formed by reaction of sulphur with sodium carbonate. K. E. RUSSELL

DIELECTRIC DEVICES

AN informal residential conference on dielectric devices was held in the Electrical Engineering Department of the University of Birmingham during September 14–17, 1959, inclusive, and was attended by representatives from universities, Government establishments and industry. The aims of the conference were to give those participating a broad overall picture of this sector of solid-state physical electronics, to discuss present trends and new ideas connected with the investigation and exploitation of dielectrics, and to stimulate research on dielectric materials and devices. In an attempt to achieve these aims each session was opened with an invited general paper which reviewed physical principles and assessed practical progress in exploitation; each session then continued with shorter papers describing current research on the properties of materials and the mechanisms of devices.

The first paper of the conference opened the session on masers and parametric amplifiers. This was given by I. M. Ross (Services Electronics Research Laboratories, Harlow), who reviewed the mechanisms of these devices and compared their more important characteristics such as gain bandwidth products and noise figures. J. C. Walling (Mullard Research Laboratories, Salfords) then described the paramagnetic resonance characteristics of chromium-doped potassium cobalticyanide and the advantages of maser operation using 'push-pull' and 'push-push' pumping. Experimental realization of both types of double pumping had been obtained in a cavity maser at a signal frequency of 2,900 Mc./s. with respective root-gain bandwidth products of 12 and 19 Mc./s. in the two cases.

In the following paper, by B. Bölger, N. J. Robinson and J. Ubbink (Philips, Eindhoven), read by J. Ubbink, the characteristics of a 1,420 Mc./s. maser were described. A three-level maser using potassium cobalticyanide at 1.4° K. with a pump frequency of 3,850 Mc./s. and a signal frequency of 1,420 Mc./s. had been constructed. A root-gain bandwidth product of 2.7 Mc./s. with a limiting power of 2×10^{-7} W. had been obtained. The final paper of this session dealt with parametric amplification and was given by L. E. Cross (Electrical Research Association, Leatherhead), who considered the use of a ferroelectric material above its Curie temperature as a possible variable reactance for this purpose. The electro-mechanical effects in ferro-electrics were briefly discussed and saturation functions derived for barium titanate and glycine sulphate. Measurements showed that glycine sulphate could not be used at 500 Mc./s. due to enhanced dielectric losses near the Curie temperature.

The second session was opened by G. F. J. Garlick (University of Hull), who reviewed the physical mechanisms of photoconductivity and luminescence. H. G. Lubszynski (E.M.I., Hayes) then explained how the use of an electron beam for making contact

to a semi-conductor offers advantages in the case of near insulators because it allows thin films of large cross-sectional area to be used with less danger of shorting. Organic luminescence and the scintillation counter formed the subjects of the next two papers. In the first of these, J. B. Birks (University of Manchester) discussed the fast and slow components of scintillations in organic materials. The former was attributed to direct singlet-state excitation, was subject to primary quenching, and hence depended on the nature of the particle. The latter was attributed to ion recombination leading to excitation of metastable triplet states, was less subject to primary quenching, and was largely independent of the nature of the particle. P. E. Gibbons and D. C. Northrop (Services Electronics Research Laboratories, Baldock) then described experiments on the long-lived decay components of anthracene scintillations showing that the characteristic times are independent of exciting particles and temperature. These and other experiments on impure anthracene show that these components probably derive from some co-operative lattice property and not a molecular one.

The opening paper of the third session was given by G. Diemer (Philips, Eindhoven), who reviewed present and potential applications of luminescence and photoconductivity in power amplification. The first research paper of the session was read by P. K. Weimer for E. E. Loebner (R.C.A., Princeton) and explained how it should be possible to escape the gain-bandwidth limitations of currently available luminescence amplifiers by using luminor elements themselves capable of modulation and amplification. The second research paper was given by J. Woods (G.E.C., Wembley), who described experiments showing that cadmium sulphide crystals doped with 1–2 per cent copper are *p*-type. Measurements of electrical conductivity, σ , Hall coefficient, R , and thermoelectric power, α , had been made from 95° K. to 380° K., and suggested transport via impurity-levels. At 300° K. it was found for $\sigma = 0.18 \text{ ohm}^{-1} \text{ cm.}^{-1}$ that $p = 1/Re = 5.6 \times 10^{18} \text{ cm.}^{-3}$, $\mu = R\sigma = 20 \text{ cm.}^2 \text{ volt}^{-1} \text{ sec.}^{-1}$, and $\alpha = 22 \mu\text{V./}^\circ\text{C.}$

Space-charge-limited current in dielectric crystals formed the topic for the fourth session. The opening paper of this session was given by G. T. Wright (University of Birmingham) and reviewed the mechanisms of space-charge-limited current in dielectrics and, on the basis of a simplified theory and available experimental data, assessed tentatively potential fields of application of space-charge-limited dielectric devices. In a short following paper, A. A. Kayali (University of Birmingham) described measurements of the temperature dependence of forward current of a number of space-charge-limited cadmium sulphide dielectric diodes. In diodes with a small trap density the current increased slowly as the temperature was lowered from 400° K. to 90° K. due to the increase of electron mobility at

the lower temperatures; above room temperature there was little variation of characteristics. In most cases the square-law dependence of current upon voltage was obeyed over this whole temperature-range. High-speed switching characteristics of the diodes were described in a paper by A. M. Conning (University of Birmingham). For both 'switch-on' and 'switch-off' operation steady-state conditions were reached in a time less than 3 μ sec., the response time of the measuring equipment; charge storage effects in the diodes were undetectable. The final paper of this session was given by G. T. Wright and discussed the design of a proposed amplifying dielectric triode, which should possess a high input resistance, a large gain-bandwidth product, and be relatively insensitive to temperature changes. Calculations showed that the presence of shallow trapping levels (< 0.30 eV.) should result in the mutual conductance at high frequencies (> 10 Mc./s.) being many times greater than at audio frequencies.

The opening paper of the fifth session was given by W. J. Merz (R.C.A., Zurich) on the subject of ferro-electricity. Present ideas of basic mechanisms in 'soft' and 'hard' ferro-electrics were reviewed and outstanding problems such as nucleation and losses above the Curie point considered. In the following paper, by K. W. Plessner (British Dielectric Research, London) and R. West (United Insulator Division, T.C.C., Chessington), the influence of the chemical composition of high permittivity ceramics upon their electrical properties was discussed. The application of chemical processes on an industrial scale was then considered. J. H. Bruce and J. R. Balmer (Radio Research Establishment, Malvern) then discussed the need for thin-film capacitors and the suitability of an evaporation method for producing these. Experimental techniques and results for silicon monoxide

capacitors were described. The last paper of the session was given by R. C. Kell (G.E.C., Wembley), who discussed piezoelectric ceramics. It had been found that niobate ceramics retained their piezoelectric properties at temperatures considerably higher than ceramics based on barium titanate and that their properties showed less variation with temperature. In particular, sodium-cadmium and lead-barium niobates were more suitable than barium titanate ceramics for use in vibration detectors, ultrasonic generators, and resonators for filter networks.

The final session of the conference included contributions from S. Duinker (Philips, Eindhoven) on a square-loop ferrite device for the fast scanning of electroluminescent cross-bar systems; from D. W. G. Ballentyne (Siemens Ediswan, Harlow) on the possible explanation of electroluminescence as a disorder phenomenon; from R. M. Glaister (G. V. Planar, Ltd., Sunbury) on relaxation polarization dielectrics; from E. A. D. White (G.E.C., Wembley) on the effects of additives on the properties of barium titanate ceramics; from J. C. Burfoot (Queen Mary College, London), who discussed switching in ferro-electrics; from Mr. F. H. Stieltjes (Philips, Eindhoven), who discussed losses in ferro-electrics with particular reference to their use in parametric amplifiers; and G. T. Wright on the trap content of dielectrics with particular reference to the characteristics of dielectric diodes.

The conference emphasized that very great potentialities exist for the exploitation of dielectrics in devices although only limited practical progress has yet been made. There is no doubt, however, that the number and diversity of outstanding problems make this a most attractive field for both fundamental and applied research.

G. T. WRIGHT

THE NATIONAL RESEARCH DEVELOPMENT CORPORATION OF GREAT BRITAIN

IN view of the stress laid on the work of the National Research Development Corporation by Prof. C. F. Carter and Prof. B. R. Williams in "Science in Industry" and of the interest in the Corporation which Lord Hailsham has already shown, the Corporation's annual report for the year July 1, 1958-June 30, 1959, will doubtless be closely examined by scientists and technologists as well as industrialists (National Research Development Corporation. Report and Statement of Accounts for the year 1st July, 1958, to 30th June, 1959. Pp. ii + 22. London: H.M. Stationery Office, 1959. 1s. 3d. net). This year's report is limited to a factual account of the year's work, but the report comments on the greater attention now paid to the Corporation's work by the scientist and industry as well as by the general public, and confidence is expressed that the Corporation's unique experience will enable it to play an ever increasing part in the application of scientific ideas to industry. Revenue from inventions rose to £189,761, and there was also a non-recurring item of £92,978 from sale of patent rights. Government departments and research councils assigned patent rights in 119 cases, compared with 86 in 1958-59, 59 of the total of 187 coming from universities and 5 from industrial research associations, compared with 49 and 1, respectively, out of 147 in 1957-58.

Of 681 inventions communicated to the Corporation during the year, compared with 612 the previous year, 287 were from Government departments and research councils, 27 from Commonwealth official organizations, 60 from universities, 8 from industrial research associations and 296 from private firms and individuals, 263 in the United Kingdom. Holdings of British and foreign patent applications totalled 2,794, including 419 United Kingdom patent applications and 580 granted patents, 820 overseas applications and 975 granted patents.

Among new projects initiated during the year or reaching a stage suitable for report are Dr. I. E. Bush's automatic apparatus for chemical treatment and scanning of chromatograms, which has speeded up procedure considerably; the development of the new antibiotics called the cephalosporins, particularly cephalosporin C, which is resistant to destruction by penicillinase; Prof. E. C. Cherry's television compression system using a variable scanning velocity so adjusted as to keep the transmitted frequencies within a desired bandwidth. An experimental system based on a 30-line picture has been constructed, and a further experimental system operating on 405 lines is being developed. A contribution has been made towards the cost of equipment to assess a proposal for an improved rolling mill, using rolls supported in