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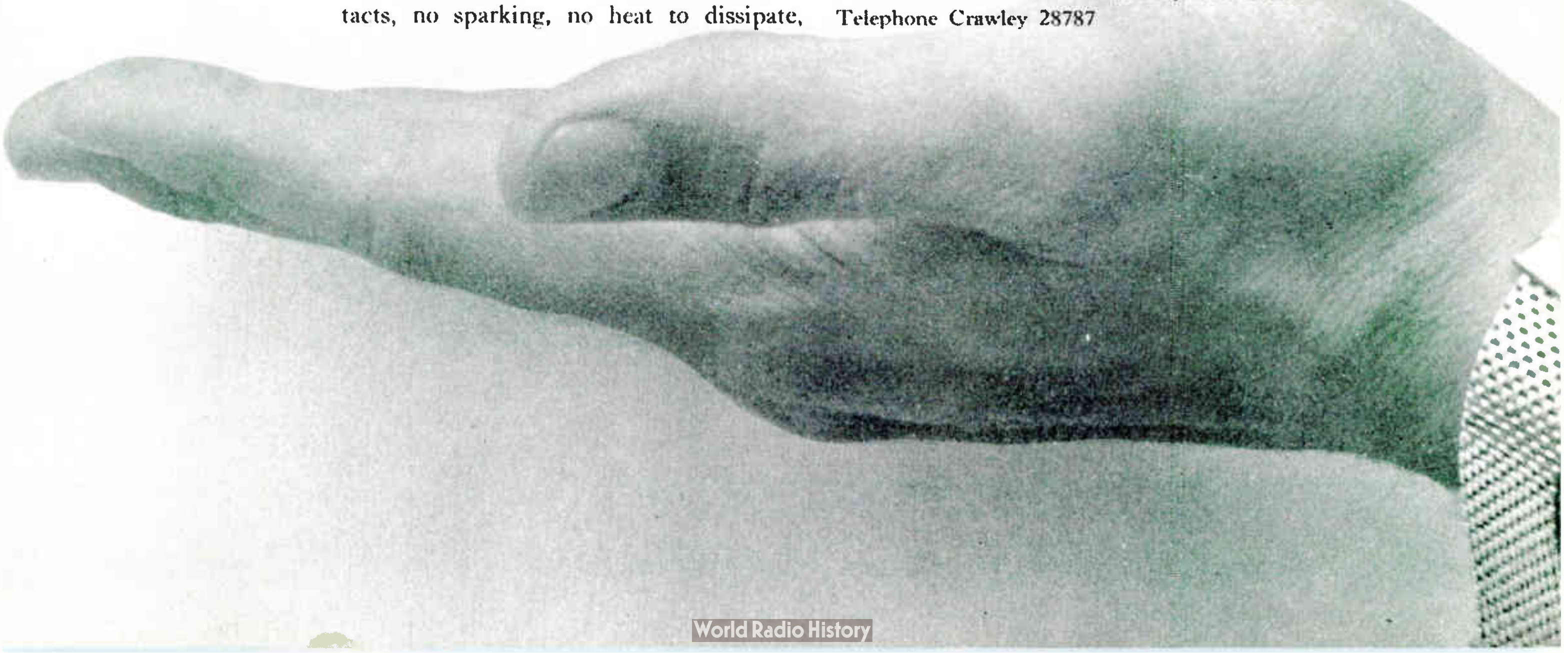

Abstracts and References

COMPILED BY THE RADIO RESEARCH ORGANIZATION OF THE DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH AND PUBLISHED BY ARRANGEMENT WITH THAT DEPARTMENT

The abstracts are classified in accordance with the Universal Decimal Classification. They are arranged within broad subject sections in the order of the U.D.C. numbers, except that notices of book reviews are placed at the ends of the sections. U.D.C. numbers marked with a dagger (†) must be regarded as provisional. The abbreviations of journal titles conform generally with the style of the World List of Scientific Periodicals. An Author and Subject Index to the abstracts is published annually; it includes a list of journals abstracted, the abbreviations of their titles and their publishers' addresses. Copies of articles or journals referred to are not available from Industrial Electronics. *Application must be made to the individual publishers concerned.*

ACOUSTICS AND AUDIO FREQUENCIES

534.14-8 : 537.311.33 **3557**

Amplification of Ultrasonic Waves in Piezoelectric Semiconductors.—D. L. White. (*J. appl. Phys.*, Aug. 1962, Vol. 33, No. 8, pp. 2547–2554.) The technique necessary for amplification is discussed, and extension to higher frequencies and more general operating conditions is considered. See 1 of January (Hutson et al.).

534.231 : 534.88 **3558**

Space Time Correlation in Spherical and Circular Noise Fields.—M. J. Jacobson. (*J. acoust. Soc. Amer.*, July 1962, Vol. 34, No. 7, pp. 971–978.) The cross-correlation of the noise field of an infinite number of white-noise sources is examined as a function of time delay, wavelength between correlation points, and frequency.

534.232 **3559**

Determination of the Parameters of a Piezoelectric Transducer from the Decay of Resonant Vibrations.—M. Redwood. (*J. acoust. Soc. Amer.*, July 1962, Vol. 34, No. 7, pp. 895–902.) The theory of the method and its limitations are discussed. It is particularly suitable for rapid measurements on transducers with low coupling coefficients ($<0{\cdot}4$).

534.232.089.6 **3560**

Shock-Wave Transducer Calibration.—R. E. Ziemer & R. F. Lambert. (*J. acoust. Soc. Amer.*, July 1962, Vol. 34, No. 7, pp. 987–988.) "The use of a shock-wave technique to obtain a frequency-response calibration of a small lead zirconate-titanate transducer is described. The response curve is obtained through numerical Fourier transformation of the recorded response to a shock-wave excitation. Sources of error and agreement with other methods of calibration are discussed."

534.417.089.6 **3561**

Hydrophone Calibration in a Vibrating Column of Liquid.—F. Schloss & M. Strasberg. (*J. acoust. Soc. Amer.*, July 1962, Vol. 34, No. 7, pp. 958–960.) The procedure has advantages over usual laboratory methods for the calibration of small low-sensitivity hydrophones: pressures up to 1 000 dyn/cm² can be produced.

534.61-14 **3562**

A Test Sound Source for Wide-Band Microphones for the Measurement of Pressure Impulses in Liquids.—W. Eisenmenger. (*Acustica*, 1962, Vol. 12, No. 3, pp. 165–172. In German.)

534.782 **3563**

Verification of the Properties of an Artificial Mouth by the Method of the Thresholds of Audibility, Intelligibility and Perception.—G. Ibba. (*Alta Frequenza*, March 1962, Vol. 31, No. 3, pp. 127–133.) The ability of an artificial mouth to reproduce speech is assessed on the basis of subjective tests.

621.395.61 : 621.382.23 **3564**

Experimental Tunnel-Diode Electromechanical Transducer Elements and their Use in Tunnel-Diode Microphones.—E. S. Rogers. (*J. acoust. Soc. Amer.*, July 1962, Vol. 34, No. 7, pp. 883–893.) The theory of a tunnel-diode transducer is developed and circuits for operation of variable-resistance or modulated negative-resistance microphones are analysed.

621.395.616 **3565**

Investigations on a Condenser Microphone with Cardioid Characteristic.—B. Weingartner. (*Acustica*, 1962, Vol. 12, No. 3, pp. 158–165. In German.) Deviations from the desired frequency response curve and directivity pattern near the lower and upper frequency limits are studied with reference to theoretical and experimental data. A method of improving low-frequency response is indicated.

621.395.625.3 : 681.84.083.84 **3566**

The Measurement of Modulation Noise.—E. Belger. (*Rundfunktech. Mitt.*, June 1962, Vol. 6, No. 4, pp. 152–154.) Modulation noise caused by inhomogeneities in the coating of magnetic recording tape is considered. The masking of this noise by the useful sound is investigated and a filter compensating for the masking effect is proposed to facilitate the measurement of noise.

AERIALS AND TRANSMISSION LINES

621.372.2 **3567**

Matrices and Equivalent Circuits of Three-Wire Transmission Lines.—M. Soldi. (*Alta Frequenza*, April & June 1962, Vol. 31, Nos. 4 & 6, pp. 219–225 & 359–374.) Detailed theoretical treatment of three-wire transmission lines for use as high-frequency circuit elements. The theory is extended to cover transmission lines with any number of conductors.

621.372.2 **3568**

The Change of Shape of Steep-Fronted Pulses by Multiple Reflections along a Transmission Line.—D. Seitzer. (*Arch. elekt. Übertragung*, June 1962, Vol. 16, No. 6, pp. 263–270.) Further investigation of the effects of irregularities in a homogeneous line on the shape of a step-voltage waveform. See also 360 of February.

621.372.2: 621.318.57: 537.312.62 **3569**

Low-Impedance Transmission System for Driving Cryogenic Circuits.—D. J. Dumin. (*Rev. sci. Instrum.*, July 1962, Vol. 33, No. 7, pp. 715–720.) The possible advantages of driving cryotron circuits with a low-impedance transmission system are discussed. Although losses are higher a reduction in the signal coupled between cables in a cryotron system is possible when low-impedance cable is used. A note is given on low-impedance pulse generator design.

621.372.22 **3570**

Circuit Arrangements at the Output of Short Distributed Inhomogeneous Lossy Lines.—W. Jutzi. (*Z. angew. Phys.*, June 1962, Vol. 14, No. 6, pp. 365–369.) Output matching conditions and circuits are discussed.

621.372.832.8 **3571**

On Some Design Problems of a Star-Type Ferrite Circulator.—S. J. Lewandowski. (*J. Instn Telecommun. Engrs, India*, March 1962, Vol. 8, No. 2, pp. 103–106.) Theory developed by Auld (26 of 1960) was used as a basis for an experimental investigation of the circulator. Modifications were made to improve the wide-band operation.

621.372.851: 621.385.632.19 **3572**

Diaphragm-Loaded Waveguides as Delay Lines.—A. Fiebig. (*Arch. elekt. Übertragung*, June 1962, Vol. 16, No. 6, pp. 283–290.) The advantages are discussed of diaphragm-loaded waveguide for use as delay-line systems in travelling-wave tubes operating at extremely high frequencies. The design of a multiple-beam delay line and experimental investigations are described.

621.372.852.22 **3573**

Modes in Rectangular Guides Loaded with Magnetized Ferrite.—G. Gerosa. (*Proc. Inst. Radio Engrs*, Aug. 1962, Vol. 50, No. 8, pp. 1826–1827.) The analysis given shows that one of the modes found by Seidel & Fletcher (757 of 1960) does not exist.

621.372.852.323 **3574**

High-Power Resonance Isolators.—F. W. Smith. (*Proc. Instn elect. Engrs, Part B*, Sept. 1962, Vol. 109, No. 47, pp. 420–429.) A method is described for improving the power-handling capacity of resonance-absorption isolators. Performance data are given on X-band isolators for handling powers >2 kW with 25% load reflection, which maintain their low-power characteristics.

621.372.853: 537.56 **3575**

Coupling of Modes between a Slow-Wave Plasma Mode and a Helix.—S. F. Paik. (*J. appl. Phys.*, Aug. 1962, Vol. 33, No. 8, pp. 2468–2473.) Propagation characteristics of a transmission system consisting of a plasma column and coaxial helix are analysed. Results are compared with those obtained by Bulgakov et al. (*Zh. tekh. Fiz.*, July 1960, Vol. 30, No. 7, pp. 840–850.)

621.396.67:621.396.621.22:621.397.62 **3576**

Communal Aerials for Television Reception in Adjacent Channels.—H. Licht. (*Rundfunktech. Mitt.*, June 1962, Vol. 6, No. 4, pp. 145–151.) The design of aerial installations suitable for the reception of transmissions in adjacent frequency channels within a given band is discussed, allowing for the problems arising from differences in signal level and direction of incidence at the aerial. Particular care is needed in the adjustment of receivers.

621.396.67: 621.396.946 **3577**

The Importance of 'Cold' Aerials for Space Communications.—A. Fournier & P. Chavance. (*Rev. tech. Comp. franç. Thomson-Houston*, June 1962, No. 36, pp. 43–53.) The equivalent noise temperature of aerials is considered and, in particular, Cassegrain and horn-reflector aerials are compared.

621.396.67.095(204): 621.396.944 **3578**

Dipole Radiation in a Conducting Half-Space.—R. K. Moore & W. E. Blair. (*J. Res. nat. Bur. Stand.*, Nov./Dec. 1961, Vol. 65D, No. 6, pp. 547–563.) Theoretical investigation of the problem of communication between aerials submerged in a conducting medium such as sea-water. The analysis is given in terms of a dipole radiating in a conducting half-space separated by a plane boundary from a dielectric half-space.

621.396.673 **3579**

Measurements of Low-Angle Radiation from a Monopole.—A. C. Wilson. (*J. Res. nat. Bur. Stand.*, Nov./Dec. 1961, Vol. 65D, No. 6, pp. 641–645.) Determination, by scale model techniques, of the effectiveness of a ground system of long-wire radials to obtain low angles of radiation. Measurements were made at 400 Mc/s with a base-driven vertical monopole and a target transmitter aerial at a distance of 200 λ.

621.396.674.3 **3580**

Transient Response of a Dipole Antenna.—S. P. Morgan. (*J. math. Phys.*, May/June 1962, Vol. 3, No. 3, pp. 564–565.) The current excited by a step-function voltage across an infinitesimal centre gap is derived using a double Fourier transformation.

621.396.674.3: 551.510.535 **3581**

The Impedance of a Short Cylindrical Dipole in the Ionosphere.—E. N. Bramley. (*Planet. Space Sci.*, Aug. 1962, Vol. 9, pp. 445–454.) Theoretical expressions are obtained for the dipole impedance in (*a*) an isotropic conducting medium, (*b*) a magneto-ionic medium, and are used to calculate numerical values for an aerial in the ionosphere.

621.396.677.3.012.12 **3582**

Phased-Array Co-ordinate Transformations.—J. H. Best. (*Microwave J.*, July 1962, Vol. 5, No. 7, pp. 51–54.) A three-dimensional presentation is needed to show the radiation pattern of planar phased arrays adequately. Plotting power contours on a spherical coordinate system is the most practical way of doing this. The particular advantages and the transformation formulae for three such systems are given.

621.396.677.43 **3583**

Rhombic Aerial Design: Two-Tiered Array.—F. J. Norman. (*Electronic Technol.*, Sept. 1962, Vol. 39, No. 9, pp. 337–346.) Field measurements of parameters indicate that the theoretical directivity patterns are achieved in practice. Graphical procedures for determining the gain and the shape of the main lobe and minor lobes are given.

621.396.677.7 **3584**

Radiation from a Magnetic Line Dipole Source of Finite Width.—L. W. Zelby. (*Proc. Inst. Radio Engrs*, Aug. 1962, Vol. 50, No. 8, pp. 1848–1849.) Analysis to determine the conditions for launching a surface wave.

621.396.677.85 **3585**

Electromagnetic Scattering from Radially Inhomogeneous Spheres.—R. J. Garbacz. (*Proc. Inst. Radio Engrs*, Aug. 1962, Vol. 50, No. 8, p. 1837.) The equations for the spherical Luneberg lens given by Tai (430 of 1961) are used as a basis of a method of determining scattering patterns, which is suitable for high-speed computer calculation.

AUTOMATIC COMPUTERS

681.142 **3586**

Improved Electronic Differentiator has Low Noise Factor.—N. D. Diamantides. (*Electronics*, 27th July 1962, Vol. 35, No. 30, pp. 46–47.) A 2:1 improvement in noise factor is achieved using the circuit configuration described which incorporates an extra amplifier, providing a time delay, and avoids a series input capacitor.

681.142: 621.318.134 **3587**

The Measurement and Reduction of Noise in Coincident-Current Core Memories.—P. Cooke & D. C. Dillistone. (*Proc. Instn elect. Engrs, Part B*, Sept. 1962, Vol. 109, No. 47, pp. 383–389.)

681.142: 621.382.2/.3 **3588**

Transistor-Diode Static Switching Units.—J. F. Young. (*Electronic Engng*, Sept. 1962, Vol. 34, No. 415, pp. 595–599.) The advantages of replacing resistors by diodes in the input of transistor NOR circuits are noted and operating conditions are discussed.

CIRCUITS AND CIRCUIT ELEMENTS

621.372.413: 537.312.62 **3589**

Measurements on Two Nb Superconductive R.F. Cavities.—L. Rinderer,

J. Rüfenacht & A. Susini. (*Phys. Lett.*, 1st Sept. 1962, Vol. 2, No. 3, pp. 119–120.) The construction of the cavities, which are tuned to 270 Mc/s, is described and results of measurements made on them are given.

621.372.44 **3590**

Dependence of Parametric Element Nonlinearity on Tuning Circuit.—G. H. B. Thompson: A. L. Helgesson. (*Proc. Inst. Radio Engrs*, Aug. 1962, Vol. 50, No. 8, pp. 1845–1846.) Comment on 45 of January and author's reply.

621.372.44 **3591**

Varactor Charge Voltage Expansions for Large Pumping Conditions.—A. L. Helgesson. (*Proc. Inst. Radio Engrs*, Aug. 1962, Vol. 50, No. 8, pp. 1846–1847.) The results given earlier (45 of January) are extended to high-level pumping.

621.372.5/.6 **3592**

Narrow-Band R.F. Networks.—A. Susini. (*Electronic Technol.*, Sept. 1962, Vol. 39, No. 9, pp. 357–361.) A simplified treatment using the pole-zero approach.

621.372.54: 621.315.212 **3593**

V.H.F. Notch Filters: T-Type Coaxial-Line Construction.—W. Wharton & R. E. Davies. (*Electronic Technol.*, Sept. 1962, Vol. 39, No. 9, pp. 332–336.) The theory of the T-type coaxial notch filter first described by Sosin (1162 of 1953) is presented and design curves for practical filters are given.

621.372.55 **3594**

A Technique of Equalizing Parabolic Group Delay.—R. M. Kurzrok. (*Proc. Inst. Radio Engrs*, Aug. 1962, Vol. 50, No. 8, p. 1840.) A technique applicable to r.f. and i.f. amplifier chains is outlined in which all-pass equalizing networks are avoided by using single- and double-tuned circuits in alternate coupling networks.

621.372.56.018.756 **3595**

Attenuators for High-Frequency Pulses.—H. L. Stadler. (*Rev. sci. Instrum.*, July 1962, Vol. 33, No. 7, p. 761.) A note on the design of an asymmetric Π attenuator.

621.373: 621.372.2: 621.372.44 **3596**

Tunnel Diode Loaded by a Shorted Transmission Line.—M. H. Steward: L. Nagumo & M. Shimura. (*Proc. Inst. Radio Engrs*, Aug. 1962, Vol. 50, No. 8, pp. 1830–1833.) Correction to and comment on 3669 of 1961 with authors' reply.

621.373: 621.372.44: 681.142 **3597**

Amplitude Limiting and Hysteresis of Parametron Oscillations.—E. Völcker. (*Elektronik*, Jan., Feb., April & Sept. 1962, Vol. 11, Nos. 1, 2, 4 & 9, pp. 1–4, 47–49, 117–120 & 262–265.) Theoretical treatment of various modes of operation of the parametron [see e.g. 3588 of 1959 (Goto)].

621.373.421.11 **3598**

Design of Temperature-Compensated Tuned Circuits.—O. Schwelb. (*Electronic Technol.*, Sept. 1962, Vol. 39, No. 9, pp. 347–352.) Formulae are given from which variable tuned circuits can be designed to cover a prescribed frequency range with a given maximum temperature coefficient.

621.373.52 **3599**

Designing Class-C Transistor *LC* Oscillators.—P. Laakmann. (*Electronics*, 27th July 1962, Vol. 35, No. 30, pp. 42–45.) An analysis with an example of design illustrating the advantages of the earthed-collector Hartley circuit.

621.374.4: 538.569.4 **3600**

Resonant Harmonic Generation in Ruby.—C. M. Kellington. (*Phys. Rev. Lett.*, 15th July 1962, Vol. 9, No. 2, pp. 57–58.) An experiment is described in which harmonic generation occurs in a medium which is resonant with respect to both the fundamental and the harmonic.

621.374.4: 621.372.44 **3601**

Generation of Harmonics with Varactor Diodes.—G. B. Stracca. (*Alta Frequenza*, March 1962, Vol. 31, No. 3, pp. 134–149.) The analysis is given for an ideal varactor diode used as a harmonic generator at high signal levels. Experimental results are compared with the theoretical characteristics. For English version see *ibid.*, May 1962, Vol. 31, No. 5, pp. 294–307.

621.374.4: 621.372.44 **3602**

Analysis of Frequency Multipliers with 'Varactor' Diodes.—M. Vadnjal & C. Dragone. (*Alta Frequenza*, March 1962, Vol. 31, No. 3, pp. 150–157.) The general analysis given is applied to the calculation of load and source impedance for optimum output from the frequency multiplier.

621.374.4: 621.372.44 **3603**

Similarity Considerations for Varactor Multipliers.—A. Uhlir, Jr. (*Microwave J.*, July 1962, Vol. 5, No. 7, pp. 55–59.) A dimensional analysis of the performance of varactors as harmonic generators shows that a better equivalent circuit is needed to represent the varactor at v.h.f.

621.374.4: 621.382.23 **3604**

A Tunnel-Diode Wide-Band Frequency-Doubling Circuit.—J. H. Burbo. (*Proc. Inst. Radio Engrs*, Aug. 1962, Vol. 50, No. 8, p. 1850.) Methods of stabilizing the circuit described by Neu (767 of March) are mentioned.

621.375.4 **3605**

Output Impedance Compensation of Common-Emitter Stage.—S. S. Hakim. (*Electronic Technol.*, Sept. 1962, Vol. 39, No. 9, pp. 353–356.) By shunting the output of a common-emitter stage with a series *RL* circuit it is possible to maintain the impedance purely resistive for frequencies up to about $f_\alpha/5$.

621.375.4.012.8 **3606**

Analytical Investigation of the Hybrid-Π Equivalent Circuit of a Transistor as an Amplifier at Radio Frequencies.—V. Banfi. (*Alta Frequenza*, April 1962, Vol. 31, No. 4, pp. 210–218.)

621.375.4.018.78: 621.372.632 **3607**

Experimental Investigations and Calculations on Distortion and Mixing Processes in Transistor Stages at Low Frequencies.—J. S. Vogel & M. J. O. Strutt. (*Arch. elekt. Übertragung*, June 1962, Vol. 16, No. 6, pp. 291–295.) An accurate method for computing the distortion effects in transistor circuits with low source and load impedance is given. See also 2892 of 1961.

621.375.43.024 **3608**

Thermal Negative Feedback in a Transistor Amplifier for Direct Current.—G. Faini & O. Svelto. (*Alta Frequenza*, April 1962, Vol. 31, No. 4, pp. 206–209.) An experimental amplifier is described in which negative feedback at extremely low frequencies is produced by thermal effects.

621.375.9: 538.569.4 **3609**

General Considerations on the Three-Level Solid-State Microwave Maser.—M. Bidault. (*Rev. tech. Comp. franç. Thomson-Houston*, June 1962, No. 36, pp. 55–109.) Operation of the maser is summarized and the physical properties of maser materials and related microwave components are reviewed.

621.375.9: 538.569.4 **3610**

Operation of a Travelling-Wave Maser in a Transverse-Field Superconducting Electromagnet.—W. G. Nilsen. (*J. appl. Phys.*, Aug. 1962, Vol. 33, No. 8, pp. 2522–2523.) A 6-Gc/s travelling-wave maser showed a net gain of 30 db with 3-db bandwidth of about 20 Mc/s.

621.375.9: 538.569.4: 621.3.018.41 (083.74) **3611**

Ammonia Maser on the 3,2 Line as a Frequency Standard: Part 1.—Shimoda & Kohno. (See 3812.)

621.375.9: 621.372.44 **3612**

Investigation of an Experimental Travelling-Wave Parametric Amplifier.—R. Mavaddat & F. J. Hyde. (*Proc. Instn elect. Engrs, Part B*, Sept. 1962, Vol. 109, No. 47, pp. 405–413.) The effect of mismatch at source and load is investigated. The signal gain obtainable with the experimental amplifier was of the order of 10 db, and the bandwidth approximately 3 Mc/s with the double-channel noise factor $<1\cdot1$ at mid-band (6·7 Mc/s).

621.375.9: 621.372.44 **3613**

Some Properties of Parametric Systems with Great Depth of Modulation: Part 1—Theory.—J. B. Gunn. (*Solid-State Electronics*, July/Aug. 1962, Vol. 5, pp. 181–204.) The behaviour of a resonant system in which the resonance frequency is varied slowly and periodically, and the practical limitations of its performance as an amplifier are discussed.

621.375.9: 621.372.44 **3614**

Parametric Amplifiers using Diodes: Type TH.D.20.—M. Baril. (*Rev. tech. Comp. franç. Thomson-Houston*, June 1962, No. 36, pp. 111–127.) Two low-noise amplifiers, one for the range 1 250–1 350 Mc/s and the other for 3 100 Mc/s, are described.

621.375.9: 621.372.44: 621.385.6 **3615**

Graphical Expressions of Synchronous Conditions in the Transverse-Type Electron-Beam Parametric Amplifier.—K. Kakizaki. (*Proc. Inst. Radio Engrs*, Aug. 1962, Vol. 50, No. 8, pp. 1850–1851.)

621.375.9: 621.382.23 **3616**

Design of a Series-Tuned Negative-Resistance Amplifier.—J. C. Paul. (*Semiconductor Prod.*, June 1962, Vol. 5, No. 6, pp. 29–35.) Analytical and graphical design procedures are presented for a low-level low-noise tunnel-diode preamplifier for 3 Mc/s which, together with the bias supply, can be built into a very small unit.

621.375.9: 621.382.23 **3617**

Noise Figure of Moody & Wacker's Broad-Band Tunnel-Diode Amplifier.—A. van der Ziel. (*Proc. Inst. Radio Engrs*, Aug. 1962, Vol. 50, No. 8, p. 1844.) See 2141 of 1961.

621.375.9: 621.382.23 **3618**

Nonlinear Distortion in Tunnel-Diode Amplifiers.—R. M. Kurzrok & A. Newton. (*Proc. Inst. Radio Engrs*, Aug. 1962, Vol. 50, No. 8, pp. 1853–1854.) An approximate theoretical analysis.

GENERAL PHYSICS

530.162: 621.391.822 **3619**

Thermal Noise in Linear, Lossy, Electromagnetic Media.—M. Vanwormhoudt & H. A. Haus. (*J. appl. Phys.*, Aug. 1962, Vol. 33, No. 8, pp. 2572–2577.) The results of an earlier paper [2145 of 1961 (Haus)] are generalized to nonuniform media.

537.311: 061.3 **3620**

Report on the Symposium on Electronic Tunnelling in Solids, Philadelphia, 1961.—E. O. Kane. (*J. Phys. Chem. Solids*, Jan./Feb. 1962, Vol. 23, pp. 173–180.) A summary of the proceedings of the meeting 30th–31st January. References are given to published material.

537.311.33 **3621**

Density Matrix Approach to a Simple Hot-Electron Problem.—A. Hasegawa & J. Yamashita. (*J. Phys. Chem. Solids*, July 1962, Vol. 23, pp. 875–880.) A transport theory of non-ohmic conductivity in semiconductors is developed in a form which is closely related to the Kohn-Luttinger theory of ohmic conductivity.

537.311.33 **3622**

Impurity Effects on the Plasma Oscillation of an Electron Gas.—Y. H. Ohtsuki. (*Progr. theor. Phys.*, May 1962, Vol. 27, No. 5, pp. 1082–1083.) The effects of impurities on the oscillation damping factor are calculated.

537.311.33: 538.63 **3623**

A Possible Origin of A.C. Current through Oscillating Cylindrical Electron-Hole Plasma.—T. Misawa. (*Jap. J. appl. Phys.*, July 1962, Vol. 1, No. 1, pp. 67–69.) Glicksman (1197 of April) proposed unstable helical perturbations in carrier density as an origin. It is argued that a.c. current will only result if the specimen is cylindrically asymmetric, or in an inclined magnetic field.

537.312.62 **3624**

The Solution of a Transition Problem in a Superconducting Strip.—W. Liniger. (*J. math. Phys.*, May/June 1962, Vol. 3, No. 3, pp. 578–586.)

537.312.62: 535.215: 621.318.57 **3625**

Radiation-Induced Transport of Magnetic Flux along a Superconducting Sheet.—J. F. Marchand & J. Volger. (*Phys. Lett.*, 1st Sept. 1962, Vol. 2, No. 3, pp. 118–119.) The normally conductive area formed by a spot of light on a sheet of superconducting material is probably due to a local heating effect. Flux from a magnet near the sheet can be isolated in such an area and transported about the sheet by moving the illuminated region, a procedure which can be regarded as the action of a flux pump. The flux can be 'set' at any point by switching off the light source.

537.525 **3626**

Build-Up of Electron Density in Neon-Argon Gas Discharges in Pulsed Microwave Fields.—M. Kumagai & T. Tsukishima. (*J. phys. Soc. Japan*, July 1962, Vol. 17, No. 7, pp. 1204–1205.)

537.525: 621.391.822 **3627**

Radio-Frequency Noise of an Immersed Langmuir Probe.—R. D. Sears & J. J. Brophy. (*J. appl. Phys.*, Aug. 1962, Vol. 33, No. 8, pp. 2583–2587.) The spectrum of noise from 50 kc/s to 10 Mc/s in a cold-cathode Ne discharge is examined.

537.56 **3628**

Transport Phenomena in a Nonuniform Slightly Ionized Gas.—S. Zivanovic & M. S. Sodha. (*Progr. theor. Phys.*, June 1962, Vol. 27, No. 6, pp. 1128–1136.) Solution of Boltzmann's equation gives electric and thermal currents in varying electric and static magnetic fields. The electron energy distribution is non-Maxwellian if gradients occur in n_e and ν.

537.56 **3629**

Containment of Plasmas by High-Frequency Electric Fields.—M. Ericson, C. S. Ward, S. C. Brown & S. J. Buchsbaum. (*J. appl. Phys.*, Aug. 1962, Vol. 33, No. 8, pp. 2429–2434.) A cylindrical plasma column was produced in hydrogen by a microwave electric field crossed with a static magnetic field. Under certain conditions the plasma appeared as a stable cylindrical column with diameter as small as ¼ that of the discharge tube. The experimentally observed properties of this 'constricted' discharge can be explained by treating the plasma as a compressible dielectric medium.

537.56 **3630**

Electron Temperature in Partially Ionized Gases Subject to Intense A.C. Fields.—S. Visvanathan. (*J. appl. Phys.*, Aug. 1962, Vol. 33, No. 8, pp. 2481–2483.) A strong electric field applied to a plasma produces electrons with a temperature considerably higher than the temperature of the neutral gas in the plasma.

537.56: 537.533 **3631**

The Interaction of Charged-Particle Beams with Plasma.—Ya. B. Fainberg. (*Atomnaya Energiya*, Oct. 1961, Vol. 11, No. 4, pp. 313–335. English translation, *J. nuclear Energy, Part C*, June 1962, Vol. 4, No. 3, pp. 203–220.) Instability and nonlinear effects in beam-plasma interaction are discussed with reference to the acceleration of charged particles and the generation and amplification of microwaves. 79 references.

537.56: 537.533 **3632**

Electromagnetic Properties of a Plasma-Beam System.—J. Neufeld. (*Phys. Rev.*, 15th July 1962, Vol. 127, No. 2, pp. 346–359.) A continuation of earlier work on the interaction of an electron beam with a cold plasma [see e.g. 2154 of 1961 (Neufeld & Doyle)], and an extension to the case of a thermal plasma.

537.56: 537.533 **3633**

Properties of a Plasma Created by an Electron Beam.—P. Hedvall. (*J. appl. Phys.*, Aug. 1962, Vol. 33, No. 8, pp. 2426–2429.) The beam and plasma were confined by an axial magnetic field. Types of oscillation that occurred are discussed.

537.56: 538.566 **3634**

Experimental Two-Beam Excitation of Plasma Oscillations.—M. J. Kofoid. (*Phys. Fluids*, June 1962, Vol. 5, No. 6, pp. 712–720.) Further tests made since the previous paper (3057 of 1960) are described and an expression is derived which gives the ratio of phase velocity to electron beam velocity for the production of strong oscillations.

537.56.08: 537.533 **3635**

Microwave Probing of Ionized-Gas Flows.—R. G. Jahn. (*Phys. Fluids*, June 1962, Vol. 5, No. 6, pp. 678–686.) A transverse microwave beam device is described and a technique is outlined for examining the build-up of ionization behind a strong shock wave in A.

538.114 **3636**

Use of Green Functions in the Theory of Ferromagnetism.—R. A. Tahir-Kheli & D. ter Haar. (*Phys. Rev.*, 1st July 1962, Vol. 127, No. 1, pp. 88–100.)

Part 1—General Discussion of the Spin-*S* Case.—Green's functions, decoupled by a simple procedure are applied to the problem of a lattice at each site of which is a spin $S(S = \frac{1}{2}, 1, 3/2, 2, 5/2, 3)$. The magnetization at low, high and sub-Curie-point temperatures is obtained using the Heisenberg Hamiltonian.

Part 2—Dyson Spin Waves.—Using the Dyson Hamiltonian both with and without the interaction term, the magnetization, spin specific heat and spin-wave dispersion are obtained for low temperatures. The effect of higher-order decoupling is also considered. The results for cubic lattices agree reasonably with other theories; the decoupling seems to be more exact for larger *S*.

538.3 **3637**

A General Method of Representation of Electromagnetic Fields.—G. Borgiotti. (*Alta Frequenza*, April 1962, Vol. 31, No. 4, pp. 226–234.) The method is based on simple properties of vector space and Fourier transforms. Various types of representation are obtained by changing the vector basis of reference of the two-dimensional space considered. For English version see *ibid.*, May 1962, Vol. 31, No. 5, pp. 285–293.

538.311 **3638**

The Electromagnetic Field of a Straight Current-Carrying Insulated Wire with Bare Ends Laid Parallel to the Surface in Sea-Water in Three-Layer Space: Air, Water, Earth.—H. Buchholz. (*Arch. Elektrotech.*, 20th June & 25th July 1962, Vol. 47, Nos. 2 & 3, pp. 80–105 & 133–148.)

Part 1: The D.C. Case.

Part 2: The A.C. Case for any Frequencies.

538.56 : 531.6 **3639**

Direct Transmission of Mechanical Energy by means of Electromagnetic Waves.—G. Latmiral & G. Franceschetti. (*Alta Frequenza*, Feb. 1962, Vol. 31, No. 2, pp. 78–81. In English.) The ponderomotive forces and torques exerted on a dipole by a linearly or circularly polarized wave are calculated. The amount of mechanical energy that can be directly transmitted from a transmitting to a receiving aerial is shown to be the energy equivalent of the Doppler effect.

538.561 : 537.56 **3640**

Microwave Radiation from a Magnetoplasma.—S. Miyoshi. (*J. phys. Soc. Japan*, July 1962, Vol. 17, No. 7, pp. 1206–1207.) Difficulty in measuring the electron density of the plasma [see 3336 of 1961 (Hirshfield & Brown)] is overcome by using an interferometer in the 8-mm-λ region.

538.566 : 537.56 **3641**

Electromagnetic Waves in a Bounded, Anisotropic Plasma.—K. A. Graf & M. P. Bachynski. (*Canad. J. Phys.*, July 1962, Vol. 40, No. 7, pp. 887–905.) A theoretical study of the interaction of a plane e.m. wave with a flat uniform free-space/plasma interface in a static magnetic field. Values are listed of the attenuation and phase constants for each of the two possible waves in the plasma.

538.569.4 : 535.853 **3642**

Use of Travelling-Wave Helices in E.S.R. and Double Resonance Spectrometers.—R. H. Webb. (*Rev. sci. Instrum.*, July 1962, Vol. 33, No. 7, pp. 732–737.) The use of a travelling-wave helix for concentrating microwave fields is discussed, with special attention to its application for electron spin resonance and Overhauser effects.

538.569.4 : 538.221 **3643**

Ferrimagnetic Resonance with Orthogonal and Parallel Pumping.—R. M. White & E. Schlömann. (*J. appl. Phys.*, Aug. 1962, Vol. 33, No. 8, pp. 2437–2438.) The threshold of nonlinear absorption due to unstable growth of certain spin waves is calculated for the case of an r.f. field applied orthogonally to the d.c. field, with another r.f. field of twice the frequency simultaneously applied parallel to the d.c. field.

538.569.4 : 538.222 **3644**

Magnetic Resonance with Strong Radio-Frequency Fields in Solids.—I. Solomon & J. Ezratty. (*Phys. Rev.*, 1st July 1962, Vol. 127, No. 1, pp. 78–87.) Redfield's proposal of a spin temperature in the rotating frame is verified independently of a relaxation theory. The technique gives a usable signal in solids for which the ordinary absorption signal is almost undetectable.

538.569.4 : 621.375.9 : 535.61-15 **3645**

Infrared Spectroscopy using Stimulated-Emission Techniques.—C. K. N. Patel, W. R. Bennett, Jr, W. L. Faust & R. A. McFarlane. (*Phys. Rev. Lett.*, 1st Aug. 1962, Vol. 9, No. 3, pp. 102–104.) Optical maser oscillation has been obtained in each of the noble gases; 14 transitions have been observed in the wavelength range 1·5–2·2 μ.

538.569.4 : 621.375.9 : 535.61-15 **3646**

Optical Maser Emission from Trivalent Praseodymium in Calcium Tungstate.—A. Yariv, S. P. S. Porto & K. Nassau. (*J. appl. Phys.*, Aug. 1962, Vol. 33, No. 8, pp. 2519–2521.)

538.569.4 : 621.375.9 : 535.61-2 **3647**

Optical-Pumping Cavity Construction Technique.—R. H. Hronik, R. C. Jones & C. J. Bronco. (*Rev. sci. Instrum.*, July 1962, Vol. 33, No. 7, pp. 776–777.) A technique for constructing elliptical reflectors of any size by use of simple machine settings is described.

538.569.4 : 621.375.9 : 535.61-2 **3648**

Optical Mixing of Coherent and Incoherent Light.—A. W. Smith & N. Braslau. (*IBM J. Res. Develop.*, July 1962, Vol. 6, No. 3, pp. 361–362.) The signal from a ruby maser has been mixed with quite broad and relatively weak spectral lines of a mercury lamp, using a KDP crystal 0·6 cm thick.

538.569.4 : 621.375.9 : 535.61-2 **3649**

Theoretical Considerations on Millimetre-Wave Generation by Optical Frequency Mixing.—J. R. Fontana & R. H. Pantell. (*Proc. Inst. Radio Engrs*, Aug. 1962, Vol. 50, No. 8, pp. 1796–1800.) The conversion efficiency obtainable with different types of nonlinear media is considered. Nonlinear passive resistive elements may have efficiencies up to 25%, regardless of frequency ratio, and a diode characteristic would give optimum results.

538.569.4 : 621.375.9 : 535.61-2 **3650**

Microwave Photomixing of Optical Maser Outputs with a *p-i-n*-Junction Photodiode.—H. Inaba & A. E. Siegman. (*Proc. Inst. Radio Engrs*, Aug. 1962, Vol. 50, No. 8, pp. 1823–1824.) Experimental results are given on the operation of a photodiode as a mixer in an optical superheterodyne system using microwave-modulated light.

538.569.4 : 621.375.9 : 535.61-2 **3651**

Optical Harmonic Frequency Ratio Measurements.—I. D. Abella. (*Proc. Inst. Radio Engrs*, Aug. 1962, Vol. 50, No. 8, pp. 1824–1825.) Simultaneous observation of the fundamental and second harmonic produced by a high-intensity ruby maser does not indicate discrepancies in the expected frequency ratio, within experimental limits and allowing for purely instrumental shifts.

538.569.4 : 621.375.9 : 535.61-2 **3652**

Single-Sideband Suppressed-Carrier Modulation of Coherent Light Beams.—C. F. Buhrer, V. J. Fowler & L. R. Bloom. (*Proc. Inst. Radio Engrs*, Aug. 1962, Vol. 50, No. 8, pp. 1827–1828.) The electro-optic effect of KDP crystals [see also 3430 of 1961 (Kaminow)] is used in the modulator described, which has been tested at a.f. for modulating the light produced by a gas laser.

538.569.4 : 621.375.9 : 535.61-2 **3653**

A Total-Reflection Solid-State Optical-Maser Resonator.—L. Bergstein, W. Kahn & C. Shulman. (*Proc. Inst. Radio Engrs*, Aug. 1962, Vol. 50, No. 8, p. 1833.) The configuration proposed uses total internal reflection for the light beam in the resonator and frustrated total reflection via a coupling prism for the output coupling. The system may be used to support two mutually independent resonance waves travelling in opposite directions.

538.569.4 : 621.375.9 : 535.61-2 **3654**

A Method for Calibration of Laser Energy Output.—A. L. Glick. (*Proc. Inst. Radio Engrs*, Aug. 1962, Vol. 50, No. 8, p. 1835.) The energy output is calibrated by attenuating the laser beam with neutral filters and directing it into a phototube; the current produced is then integrated.

538.569.4 : 621.375.9 : 535.61-2 **3655**

Generation and Radiation of Ultramicrowaves by Optical Mixing.—O. P. Gandhi. (*Proc. Inst. Radio Engrs*, Aug. 1962, Vol. 50, No. 8, pp. 1829–1830.) The nonlinear mixing system discussed provides for the generation of the beat frequency between laser beams operating at different temperature, and for the highly directional radiation of these microwaves.

538.569.4 : 621.375.9 : 535.61-2 **3656**

Direct Observation of Longitudinal Modes in the Output of Optical Masers.—R. C. Duncan, Jr, Z. J. Kiss & J. P. Wittke. (*J. appl. Phys.*, Aug. 1962, Vol. 33, No. 8, pp. 2568–2569.) Modes were observed in $U : CaF_2$ and ruby masers with a high-resolution spectrometer. Mode spacings are in reasonable agreement with theory.

GEOPHYSICAL AND EXTRATERRESTRIAL PHENOMENA

523.16 **3657**

The Solar Wind.—E. N. Parker. (*J. Res. nat. Bur. Stand.*, Nov./Dec. 1961, Vol. 65D, No. 6, pp. 537–542.) A concise review of the theory of interplanetary plasmas, fields and cosmic-ray variations, based on the solar-wind model of interplanetary dynamical processes.

523.164 **3658**

A System of Digital Analysis for Radio Astronomy using a Fully Steerable Telescope.—C. G. T. Haslam, J. G. Davies & M. I. Large. (*Mon. Not. R. astr. Soc.*, June 1962, Vol. 124, No. 2, pp. 169–178.)

523.164 **3659**

Intense Shell Sources of Radio Emission.—H. van der Laan. (*Mon. Not. R. astr. Soc.*, June 1962, Vol. 124, No. 2, pp. 179–187.) Observational evidence for the existence of shell sources is cited and conditions under which such sources might be formed are outlined.

523.164.3 **3660**

A Survey of the Anticentre Region of the Galaxy at 237 Mc/s.—R. D. Davies & C. Hazard. (*Mon. Not. R. astr. Soc.*, June 1962, Vol. 124, No. 2, pp. 147–154.)

523.164.3 **3661**

Faraday Rotation of Polarized Galactic Radio Emission.—R. Wielebinski & J. R. Shakeshaft. (*Nature, Lond.*, 8th Sept. 1962, Vol. 195, No. 4845, pp. 982–983.) Polarization measurements at 408 Mc/s of radiation from certain areas of the sky have revealed a small linearly polarized component. Variations of the direction of the phase of polarization of this component are found to be related to the Faraday rotation angle of the ionosphere. Outside the ionosphere its direction tends to be perpendicular to the galactic plane.

523.164.3 **3662**

10-cm Observations of Venus near Superior Conjunction.—F. D. Drake. (*Nature, Lond.*, 1st Sept. 1962, Vol. 195, No. 4844, p. 894.) Results confirm earlier observations in indicating little difference between surface temperatures of the illuminated and dark hemispheres of the planet.

523.164.3 **3663**

Measurements of the Polarization and Angular Extent of the Decimetre Radiation from Jupiter.—D. Morris & G. L. Berge. (*Astrophys. J.*, July 1962, Vol. 136, No. 1, pp. 276–282.)

523.164.3 **3664**

A Possible Explanation for Jovian Decametre Bursts.—S. E. Strom & K. M. Strom. (*Astrophys. J.*, July 1962, Vol. 136, No. 1, pp. 307–309.) Signals from weak r.f. sources occulted by Jupiter are focused by the Jovian atmosphere close to the earth's orbit. A correlation is shown between burst length and the apparent speed of Jupiter against the star background.

523.164.3 **3665**

Microwave Spectrum of Saturn.—F. D. Drake. (*Nature, Lond.*, 1st Sept. 1962, Vol. 195, No. 4844, pp. 893–894.) Results of observations at 10 cm λ on Saturn, combined with those of Cook et al. (135 of 1961), indicate that the emissions are almost entirely of thermal origin.

523.164.32 **3666**

Characteristics of Type III Radio Bursts.—J. M. Malville. (*Astrophys. J.*, July 1962, Vol. 136, No. 1, pp. 266–275.) Observations of the drift rate, duration, and frequency range of Type III bursts between 580 and 8 Mc/s are discussed.

523.164.32 **3667**

Association of Centimetre-Wave Bursts with Different Spectral Types of Metre-Wave Bursts of Solar Radio Emission.—M. R. Kundu. (*J. geophys. Res.*, July 1962, Vol. 67, No. 7, pp. 2695–2706.) A statistical analysis is made of the characteristics of cm-λ bursts associated with different spectral types of m-λ burst in the range 100–580 Mc/s.

523.165 **3668**

Some Features of the Response of Neutron Monitors to Low-Energy Particles Incident on the Top of the Atmosphere.—W. Webber. (*Canad. J. Phys.*, July 1962, Vol. 40, No. 7, pp. 906–923.) Comparison of primary particle flux above the atmosphere with that recorded by neutron monitors at sea level shows that low-energy primaries contribute more to sea-level measurements than was previously thought.

523.165 **3669**

Observation of the Van Allen Radiation Regions during August and September 1959: Part 4—The Outer-Zone Electrons.—R. L. Arnoldy, R. A. Hoffman & V. R. Winckler. (*J. geophys. Res.*, July 1962, Vol. 67, No. 7, pp. 2595–2612.) A report of Explorer VI data obtained when the count-rate time variations and the geomagnetic activity were low. Part 3: 1534 of May (Hoffman et al.).

523.165 **3670**

Forbush Decreases produced by Diffusive Deceleration Mechanism in Interplanetary Space.—H. Laster, A. M. Lenchek & S. F. Singer. (*J. geophys. Res.*, July 1962, Vol. 67, No. 7, pp. 2639–2643.) A Forbush decrease is explained in terms of a diffusive deceleration mechanism in turbulent interplanetary magnetic plasma clouds. Cosmic rays lose energy in an inverse Fermi mechanism and by betatron action in the weakening magnetic field of an expanding cloud.

523.165 **3671**

Detection of the Radiation Anomaly above the South Region of the Atlantic Ocean at Heights of 310–340 km.—L. V. Kurnosova, T. N. Kolobyanina, V. I. Logachev, L. A. Razorenov, I. A. Sirotkin & M. I. Fradkin. (*Isk. Sput. Zemli*, 1961, No. 8, pp. 90–93. English translation, *Planet. Space Sci.*, Aug. 1962, Vol. 9, pp. 513–516.)

523.165 **3672**

An Extremely Intense Electron Flux at 1 000-Kilometre Altitude in the Auroral Zone.—B. J. O'Brien & C. D. Laughlin. (*J. geophys. Res.*, July 1962, Vol. 67, No. 7, pp. 2667–2672.) An intense flux of 'dumped' electrons at 1 000 km altitude was observed with Injun I. No variation in flux was detected by Explorer XII at several earth radii on the same magnetic shell.

523.165: 523.75 **3673**

Measurement of the Intensity of Charged Particles after the Chromospheric Flare of the 7th July 1958.—E. V. Gorchakov & G. A. Bazilevskaya. (*Isk. Sput. Zemli*, 1961, No. 8, pp. 84–86. English translation, *Planet. Space Sci.*, Aug. 1962, Vol. 9, pp. 507–509.) Satellite data showed a marked ionization increase between the eruption and the subsequent magnetic storm.

523.165: 523.75 **3674**

The Flux of Heavy Nuclei in the July 10, 1959, Flare.—S. Biswas. (*J. geophys. Res.*, July 1962, Vol. 67, No. 7, pp. 2613–2615.) Emulsion measurements are given for the range 150–500 MeV per nucleon.

523.165: 523.75 **3675**

The Measurement of the Cut-Off Rigidity at Minneapolis using Solar Protons and α Particles from July 10, 1959, Flare.—P. S. Freier. (*J. geophys. Res.*, July 1962, Vol. 67, No. 7, pp. 2617–2626.) The solar beam at Churchill (not affected geomagnetically) is compared with the magnetically controlled flux at Minneapolis.

523.165: 523.75 **3676**

Gamma Rays from the Solar-Cosmic-Ray-Produced Nuclear Reactions in the Earth's Atmosphere and Lower Limit on the Energy of Solar Protons observed at Minneapolis.—P. D. Bhavsar. (*J. geophys. Res.*, July 1962, Vol. 67, No. 7, pp. 2627–2637.)

523.165: 550.38 **3677**

The Magnetic Field of the Quiet-Time Proton Belt.—S. I. Akasofu, J. C. Cain & S. Chapman. (*J. geophys. Res.*, July 1962, Vol. 67, No. 7, pp. 2645–2647.) The magnetic field of a model proton belt, which is analogous to that measured by Explorer XII, is computed numerically. The equatorial magnetic field at the earth's surface due to this belt is about 38 γ.

523.165: 550.385.4 **3678**

Geomagnetic-Storm Effects on Charged Particles.—T. Obayashi. (*J. Geomag. Geoelect.*, 1961, Vol. 13, Nos. 1/2, pp. 26–32.) The change in geomagnetic cut-off, for a model in which the magnetic storm is equivalent to an impressed uniform field, is calculated; it compares favourably with observations of cosmic rays and ionospheric absorption.

523.165: 550.385.4 **3679**

Cosmic-Ray Threshold Rigidities during the Magnetic Storm of November 12, 1960.—C. J. Hatton & P. L. Marsden. (*Phil. Mag.*, July 1962, Vol. 7, No. 79, pp. 1145–1156.) During the storm the magnetic threshold rigidity for particles reaching the earth was lowered all over the world. That this reduction was anisotropic in longitude is explained by streaming solar plasma drawing out the geomagnetic lines of force on the night side of the earth.

523.165: 551.594.5 **3680**

Distribution in Space of the Earth's Outer Radiation Belt and the Auroral Zones.—E. V. Gorchakov. (*Isk. Sput. Zemli*, 1961, No. 8, pp. 81–83. English translation, *Planet. Space Sci.*, Aug. 1962, Vol. 9, pp. 503–505.) The boundary of the belt and the position of maximum intensity within it located by satellite, indicate that outer-belt particles are not the cause of aurorae.

[523.5 + 551.594.5]: 621.396.677 **3681**

Some Radar Observations of Meteors and Aurorae at 300 and 500 Mc/s using a Large Radio Telescope.—D. Barber, H. K. Sutcliffe & C. D. Watkins. (*J. atmos. terr. Phys.*, July 1962, Vol. 24, pp. 585–607.)

Part 1—Observations of Meteors (pp. 585–597).

Part 2—Observations of the Aurora Borealis (pp. 599–607). The observations were made with a high-power transmitter installed on the Jodrell Bank 250-ft radio telescope.

523.746.5 **3682**

A Quick Method for Estimating the Stage of the Sunspot Cycle.—W. B. Chadwick. (*J. Res. nat. Bur. Stand.*, Nov./Dec. 1961, Vol. 65D, No. 6, pp. 637–640.) The method given is based on the maximum median hourly value of f_0F2 for each month as observed at Washington, D.C. Regression equations and standard errors are also included.

523.75 **3683**

The Solar Geophysical Events of November 1960.—T. Obayashi. (*J. Geomag. Geoelect.*, 1961, Vol. 13, Nos. 1/2, pp. 11–25.)

523.75: 523.165: 550.385.4 **3684**

Solar Magnetic Cloud Producing Cosmic-Ray Storm, Magnetic Storm and Type IV Solar Radio Outburst.—Y. Kamiya. (*J. Geomag. Geoelect.*, 1961, Vol. 13, Nos. 1/2, pp. 33–41.) An analysis of several years' data shows that eruptions on the sun accompanied by Type IV r.f. emission are the cause of the cosmic-ray storms at the earth. Magnetic storms are greatest when produced by flares near the sun's central meridian, but the intensity of cosmic-ray storms is independent of the heliographic longitude of the eruption.

550.37 **3685**

The Solar and Lunar Daily Variations of Earth Currents Near the Magnetic Equator.—R. Hutton. (*J. atmos. terr. Phys.*, Aug. 1962, Vol. 24, pp. 673–680.) One conclusion from a detailed study of equatorial earth currents is that they are enhanced by the electrojet.

550.385.4 + 551.594.5 **3686**

On the Bennett-Hulburt Hypothesis of the Origin of Magnetic Storms and Aurorae.—V. C. A. Ferraro & D. M. Willis. (*Astrophys. J.*, July 1962, Vol. 136, No. 1, pp. 288–303.) A detailed analysis and criticism of the Bennett-Hulburt hypothesis (126 of 1955). The currents in solar streams are shown to be several orders of magnitude smaller than those of even minor magnetic storms.

550.385.4: 523.75 **3687**

Dependence of Interval between Flare and Associated Sudden-Commencement Storm on Prestorm Conditions.—M. W. Haurwitz. (*J. geophys. Res.*, July 1962, Vol. 67, No. 7, pp. 2979–2982.) The time delay between a sudden commencement and its 'parent' flare is least for those s.c's which have been preceded by high magnetic activity.

550.385.4: 523.75 **3688**

On the Choice of Condition to Apply at the Boundary of the Geomagnetic Field in the Steady-State Chapman-Ferraro Problem.—J. R. Spreiter & B. R. Briggs. (*J. geophys. Res.*, July 1962, Vol. 67, No. 7, pp. 2983–2985.) A previous discrepancy in the boundary condition applicable to the steady-state Chapman-Ferraro problem is resolved, and an earlier paper (1541 of May) is amended.

551.507.362.1/.2 **3689**

The Study of the Ionosphere and Interplanetary Gas by means of Artificial Earth Satellites and Space Rockets (Methods and some Results of Radio Investigations).—Ya. L. Al'pert. (*Isk. Sput. Zemli*, 1961, No. 7, pp. 125–169. English translation, *Planet. Space Sci.*, July 1962, Vol. 9, pp. 391–433.) Measurements made since 1953 by rocket and satellite techniques are discussed. 49 references.

551.507.362.1 **3690**

A Review of Upper-Atmosphere Rocket Research in Japan.—K. Maeda & K. Hiaro. (*Planet. Space Sci.*, July 1962, Vol. 9, pp. 355–369.) A description of the launching facilities, rocket equipment and results of the current research program, with a note on future plans.

551.507.362.2 **3691**

Satellite Orbit Perturbations due to Radiation Pressure and Luni-solar Forces.—R. R. Allan. (*Quart. J. Mech. appl. Math.*, Aug. 1962, Vol. 15, Part 3, pp. 283–301.) A vectorial method is used to determine the perturbations of the orbit assuming that the perturbing body remains fixed during one revolution of the satellite.

551.507.362.2 **3692**

The Influence of Lunar and Solar Attraction on the Motion of an Artificial Earth Satellite.—A. V. Egorova. (*Isk. Sput. Zemli*, 1961, No. 8, pp. 46–56. English translation, *Planet. Space Sci.*, Aug. 1962, Vol. 9, pp. 479–490.) The perturbations are determined using Lagrange's planetary equations and taking the orbit of the perturbing body as the reference plane.

551.507.362.2 **3693**

General Solution of the Problem of the Motion of an Artificial Satellite in the Normal Field of the Earth's Attraction.—E. P. Aksenov, E. A. Grebenikov & V. G. Demin. (*Isk. Sput. Zemli*, 1961, No. 8, pp. 64–71. English translation, *Planet. Space Sci.*, Aug. 1962, Vol. 9, pp. 491–498.) The motion of a satellite in an oblate potential field is studied using generalized co-ordinates and Lagrange's equations of motion. The method of an independent variable is used for the integration.

551.510.535 + 523.164.32 **3694**

Scattering and Conversion Cross-Sections in Inhomogeneous Plasma.—M. H. Cohen. (*J. geophys. Res.*, July 1962, Vol. 67, No. 7, pp. 2729–2739.) A general scattering theory is developed for a magnetic-field-free plasma, allowing for both transverse and longitudinal waves. Special features of the cross-section formulae are discussed and ionospheric incoherent-scatter experiments and solar r.f. bursts are considered quantitatively.

551.510.535 **3695**

Corpuscular Heating of the Upper Atmosphere.—H. K. Paetzold. (*J. geophys. Res.*, July 1962, Vol. 67, No. 7, pp. 2741–2744.) Satellite drag data are used to examine the dependence of temperature on solar activity. Two-thirds of the energy influx originates from ultraviolet radiation and one-third from interplanetary corpuscles.

551.510.535 **3696**

Upper Atmosphere Turbulence Determined by means of Rockets.—J. E. Blamont & C. de Jager. (*J. geophys. Res.*, July 1962, Vol. 67, No. 8, pp. 3113–3119.) Paper presented at a symposium on fundamental problems in turbulence, Marseilles, 4th–9th September 1961. The results discussed are based on investigations with the aid of Na vapour trails at heights between 80 and 120 km.

551.510.535 **3697**

D-Region Ionization by Solar X-Rays.—I. G. Poppoff & R. C. Whitten. (*J. geophys. Res.*, July 1962, Vol. 67, No. 7, pp. 2986–2988.) By using the X-ray spectra reported by Kreplin (4097 of 1961) it is shown that X rays can make an important contribution to ionization in the range 70–90 km, at least during periods of sunspot maximum.

551.510.535 **3698**

Electron Cooling in the D Region.—A. Dalgarno & R. J. Moffett. (*Planet. Space Sci.*, July 1962, Vol. 9, pp. 355–369.) A theoretical treatment for N_2 and O_2 from which the mean rate of electron energy loss is calculated for gas temperatures in the range 100–1 000°K.

551.510.535 **3699**

The Reflection Characteristics of a Patchy Sporadic-E Layer.—J. D. Whitehead. (*J. atmos. terr. Phys.*, Aug. 1962, Vol. 24, pp. 681–684.) An explanation is given of the insensitivity of f_0E_s and f_bE_s to gain changes of an ionosonde; f_0E_s is the better measure of the peak electron density in the layer.

551.510.535 **3700**

The Thermal Balance of the Ionospheric F Region.—C. H. Cummack. (*J. atmos. terr. Phys.*, Aug. 1962, Vol. 24, pp. 691–699.) Heating of the F region by ionizing radiation, and cooling by conduction and radiation, are considered. When simplifications are made, the equations can be solved to give the variation of temperature with height and local time.

551.510.535 **3701**

Lunar Variations of Spread-F.—B. V. Krishnamurthy & B. R. Rao. (*J. atmos. terr. Phys.*, Aug. 1962, Vol. 24, pp. 742–743.) Harmonic analysis of spread-F indices at Waltair yields small lunar diurnal and semidiurnal components.

551.510.535 **3702**

Vertical Transport of Electrons during Pre-sunrise F-Layer 'Splitting'.—P. Bandyopadhyay & S. K. Chatterjee. (*Indian J. Phys.*, March 1962, Vol. 36, No. 3, pp. 124–128.) An extension of earlier work (501 of 1960). The observed splitting of the layer is associated with a strong upward movement of the upper part of the layer and also with low values of magnetic *K*-index.

551.510.535 **3703**

Ionospheric Drift Measurement.—E. Harnischmacher. (*Arch. tech. Messen*, July 1962, No. 318, pp. 147–150.) Various methods are summarized including those based on fading, meteor echoes, and fluctuations of noise from radio stars.

551.510.535: 550.382 **3704**

Study of the Geomagnetic Anomaly during Sunspot Maximum.—C. S. R. Rao. (*J. atmos. terr. Phys.*, Aug. 1962, Vol. 24, pp. 729–737.) Critical-frequency and $N(h)$ data obtained for a number of stations during September 1957 and March 1958 are used to study the geomagnetic anomaly in the F2 region.

551.510.535: 550.385 **3705**

Intensification of the Earth's Magnetic Field by Turbulence in the Ionosphere.—H. K. Moffatt. (*J. geophys. Res.*, July 1962, Vol. 67, No. 8, pp. 3071–3073.) Paper presented at a symposium on fundamental problems in turbulence, Marseilles, 4th–9th September 1961. The problem of ionospheric turbulence is treated for the case of a large-scale weak magnetic field applied to the system. Large fluctuations may arise for magnetic Reynolds number $\gg 1$.

551.510.535: 551.594.5 **3706**

Electron Precipitation accompanying Ionospheric Current Systems in the Auroral Zone.—J. R. Bascus & R. R. Brown. (*J. geophys. Res.*, July 1962, Vol. 67, No. 7, pp. 2673–2680.) Magnetic bays developing out of quiet conditions are examined to obtain information on current systems. Links with the auroral morphology of Davis (1570 of May) are suggested.

551.510.535: 551.594.5 **3707**

Time, Height, and Latitude Distribution of D Layers in the Subauroral Zone and their Relation to Geomagnetic Activity and Aurora.—A. Pedersen. (*J. geophys. Res.*, July 1962, Vol. 67, No. 7, pp. 2685–2694.) Observations of echoes in the range 60–90 km at stations in northern Sweden during disturbed periods.

551.510.535: 621.3.087.4 **3708**

Design of Panoramic Ionospheric Recorders.—L. H. Heisler & L. D. Wilson. (*J. Res. nat. Bur. Stand.*, Nov./Dec. 1961, Vol. 65D, No. 6, pp. 629–636.) Design aspects are discussed and the technical data of a transportable ionosonde are summarized (see 3709 below).

551.510.535: 621.3.087.4 **3709**

An Electronically Scanned Panoramic Ionospheric Recorder.—L. D. Wilson. (*Aust. J. appl. Sci.*, June 1962, Vol. 13, No. 2, pp. 89–97.) Linear or logarithmic sweeps of variable duration for the frequency range of 0·1–20 Mc/s or any part of that range may be made. The transmitter which operates normally at 5·5 kW ± 1 db, has a subsidiary amplifier to boost the output to 44 kW ± 3 db. See 517 of February (Heisler & Wilson).

551.510.535: 621.396.674.3 **3710**

The Impedance of a Short Cylindrical Dipole in the Ionosphere.—Bramley. (See 3581.)

551.510.535(98): 523.75 **3711**

Characteristics of Solar Energetic Particles which Excite Polar-Cap Blackouts.—K. Sinno. (*J. Geomag. Geoelect.*, 1961, Vol. 13, Nos. 1/2, pp. 1–10.) The association of S and G types of p.c.a. event (see 2977 of 1961) with flare position, geomagnetic disturbance and solar r.f. bursts is examined.

551.510.536 **3712**

'Scale Frequency' of the Exosphere.—R. L. Dowden. (*Nature, Lond.*, 8th Sept. 1962, Vol. 195, No. 4845, pp. 984–985.) The parameter 'scale frequency' is defined in terms of the whistler nose frequency and the gyro-frequency. Applications to theoretical studies on a model or real exosphere are noted.

551.594.5 **3713**

A Comparison of Auroral-Zone X-Ray Observations from Periods with Different Levels of Solar Activity.—R. R. Brown. (*J. geophys. Res.*, July 1962, Vol. 67, No. 7, pp. 2681–2684.) The comparison shows a decline in the frequency of events with solar activity.

551.594.5: 523.165 **3714**

A Charge Separation Mechanism for the Production of Polar Auroras and Electrojets.—J. W. Kern. (*J. geophys. Res.*, July 1962, Vol. 67, No. 7, pp. 2649–2665.) Charge separation in the geomagnetically trapped radiation is invoked to explain some observed phenomena associated with polar auroras and electrojet current systems.

551.594.5: 550.385.4 **3715**

Large-Scale Auroral Motions and Polar Magnetic Disturbances: Part 2—The Changing Distribution of the Aurora during Large Magnetic Storms.—S. I. Akasofu. (*J. atmos. terr. Phys.*, Aug. 1962, Vol. 24, pp. 723–727.) During the great magnetic storms of 23rd September 1957 and 11th February 1958 the northern border of auroral activity moved southwards leaving the usual region of most frequent aurorae deserted. Part 1: 198 of 1961.

551.594.6 **3716**

A Further Note on Terrestrial Extremely-Low-Frequency Propagation in the Presence of an Isotropic Ionosphere with an Exponential Conductivity/Height Profile.—J. Galejs. (*J. geophys. Res.*, July 1962, Vol. 67, No. 7, pp. 2715–2728.) Various electron-density data, particularly those relating to the night-time ionosphere, are examined with reference to the e.l.f. wave analysis of 147 of January.

551.594.6 **3717**

Duration and Spacing of Sferic Pulses.—R. F. Linfield & C. A. Samson. (*Proc. Inst. Radio Engrs*, Aug. 1962, Vol. 50, No. 8, pp. 1841–1842.) Report on an analysis of waveforms of atmospherics recorded simultaneously at two stations.

551.594.6: 539.16 **3718**

Sudden Enhancement of Atmospherics associated with High-Altitude Nuclear Explosions.—M. K. Das Gupta & A. K. Sen. (*J. atmos. terr. Phys.*, Aug. 1962, Vol. 24, pp. 739–740.) Atmospheric noise records at 120 kc/s show sudden enhancement effects associated with the Russian high-altitude nuclear explosions of 1961.

551.594.6: 551.510.536 **3719**

On the Origin of 'Very-Low-Frequency' Emissions.—H. Unz. (*J. atmos. terr. Phys.*, Aug. 1962, Vol. 24, pp. 685–689.) The magneto-ionic theory for drifting plasma is applied to the theory of the origin of v.l.f. emissions. The frequency at which there will be interaction, and possibly amplification, between two different streams of electrons is found. Physical phenomena are explained by interaction between several streams of electrons of different plasma frequency and different velocity.

551.594.6: 621.391.82 **3720**

On the Spectrum of Terrestrial Radio Noise at Extremely Low Frequencies.—Raemer. (See 3848.)

LOCATION AND AIDS TO NAVIGATION

621.396.93.029.45 **3721**

The Use of V.L.F. Transmissions for Navigation.—C. Powell. (*J. Inst. Nav.*, July 1962, Vol. 15, No. 3, pp. 277–288. Discussion.) A survey of proposed v.l.f. navigational aids, their expected performance and installation problems. The accuracies required are discussed together with other methods of providing the facilities needed for modern navigation.

621.396.932/.933: 621.391.812.63.029.45 **3722**

Effects of the Ionosphere on V.L.F. Navigational Aids.—W. T. Blackband. (*J. Res. nat. Bur. Stand.*, Nov./Dec. 1961, Vol. 65D, No. 6, pp. 575–580.) The feasibility of basing world-wide navigational aids on v.l.f. transmissions is discussed. Preliminary aircraft measurements show that fixes obtained are internally consistent to within one nautical mile at ranges between 5 000 and 6 000 miles.

621.396.962.3 **3723**

The Echo/Noise Ratio Obtainable in Radar by means of Pulse Compression.—V. Palermo : U. Tiberio. (*Alta Frequenza*, April 1962, Vol. 31, No. 4, p. 235.) Comment on 1581 of May and author's reply.

621.396.967.2: 621.396.65 **3724**

Radio-Relay Networks for the Elbe and Weser Shore-Based Radar Systems.—H. J. Kramer. (*Philips Telecommun. Rev.*, July 1962, Vol. 23, No. 3, pp. 130–146.) Radar signals are relayed in the 7-Gc/s band from radar stations to operational centres. Frequency-diversity reception methods are used. See 1530 of 1961 (le Compte et al.).

MATERIALS AND SUBSIDIARY TECHNIQUES

535.215: 546.817-31 **3725**

Overshoot in Photoconductivity of Lead Oxide.—K. E. Haq. (*J. appl. Phys.*, Aug. 1962, Vol. 33, No. 8, pp. 2606–2612.) Overshoot is due to build-up of space charge in the bulk of the material. It is only observed in the range −50 to +70°C.

535.37 : 537.226 **3726**

Dielectric Anomalies in Zinc Sulphide and Cadmium Sulphide Excited by Light.—T. Fujimura & K. Kamiyoshi. (*Sci. Rep. Res. Inst. Tohoku Univ., Ser. A*, Dec. 1961, Vol. 13, No. 6, pp. 466–476.) Details of experiments on the Debye effect in ZnS phosphors and anti-Debye effect in CdS phosphors are given. Results are interpreted in terms of a two-layer model [162 of 1952 (Koops)].

537.227 **3727**

Domain Walls Caught in Sudarés in Rochelle Salt Crystal.—K. Ohi & T. Nakamura. (*J. phys. Soc. Japan*, July 1962, Vol. 17, No. 7, p. 1195.) Simultaneous observation of both sudarés and ferroelectric domains under direct and alternating fields is reported.

537.227 : 546.431'824-31 **3728**

Some Observations on Switched Single-Crystal Barium Titanate.—D. S. Campbell. (*Phil. Mag.*, July 1962, Vol. 7, No. 79, pp. 1157–1166.) Results are given for various polarization states of an etched single crystal.

537.227 : 546.431'824-31 : 539.12.04 **3729**

Radiation Damage on $BaTiO_3$ Single Crystal.—S. Hayakawa & H. Ikushima. (*J. phys. Soc. Japan*, July 1962, Vol. 17, No. 7, pp. 1198–1199.) Experimental note on the effect of γ irradiation.

537.227 : 546.431'824-31 : 539.23 **3730**

Electron-Optical Studies of Barium Titanate Single-Crystal Films.—M. Tanaka, N. Kitamura & G. Honjo. (*J. phys. Soc. Japan*, July 1962, Vol. 17, No. 7, pp. 1197–1198.)

537.227 : 621.318.57 **3731**

Increase in Dielectric Constant during Switching in Barium Titanate and Triglycine Sulphate.—E. Fatuzzo. (*J. appl. Phys.*, Aug. 1962, Vol. 33, No. 8, pp. 2588–2596.) Measurements at frequencies up to 2 Gc/s reveal two relaxation levels, one previously measured by Landauer et al. (3759 of 1956) and a new one at much higher frequencies: 100 Mc/s for triglycine sulphate and above 2 Gc/s for $BaTiO_3$.

537.228.1/.2 **3732**

Piezoelectric Properties of Triglycine Sulphate.—T. Ikeda, Y. Tanaka & H. Toyeda. (*Jap. J. appl. Phys.*, July 1962, Vol. 1, No. 1, pp. 13–21.) Induced piezoelectricity and electrostrictive effects are examined for temperature dependence, and influence of irradiation.

537.228.1 **3733**

Rotating Disk of Piezoelectric Crystals.—H. S. Paul. (*Aust. J. appl. Sci.*, June 1962, Vol. 13, No. 2, pp. 98–106.) The mechanical stresses and electric field developed in the disk are calculated.

537.228.1 : 538.222 **3734**

The Generation of Microwave Phonons for Studying the Spin-Lattice Interaction.—P. H. Carr & M. W. P. Strandberg. (*J. Phys. Chem. Solids*, July 1962, Vol. 23, pp. 923–937.) Phonon packets were produced by the piezoelectric effect and their interaction with paramagnetic impurities in quartz was studied.

537.228.1 : 549.514.51 **3735**

Higher-Order Temperature Coefficients of the Elastic Stiffnesses and Compliances of Alpha-Quartz.—R. Bechmann, A. D. Ballato & T. J. Lukaszek. (*Proc. Inst. Radio Engrs*, Aug. 1962, Vol. 50, No. 8, pp. 1812–1822.) The frequency/temperature characteristics of AT-, BT-, CT- and DT-cut crystals are considered on the basis of new calculations of elasticity and temperature coefficients. For German version see *Arch. elekt. Übertragung*, June 1962, Vol. 16, No. 6, pp. 307–313 (Bechmann).

537.228.2 **3736**

Investigations on Ceramic Electrostrictive Materials as a Function of their State of Polarization.—K. Feher & W. Schmidt. (*Acustica*, 1962, Vol. 12, No. 3, pp. 173–179. In German.) A method is described for measuring the intrinsic energy inherent in polarized ceramic materials. An 'electrostriction constant' is determined from measurements on $BaTiO_3$ specimens.

537.311.32 **3737**

Electrons and Holes in Bismuth.—A. L. Jain & S. H. Koenig. (*Phys. Rev.*, 15th July 1962, Vol. 127, No. 2, pp. 442–446.) An examination of recent data shows that there are three electron ellipsoids and one light-hole ellipsoid in momentum space for Bi.

537.311.33 **3738**

Quantitative Measurements of Semiconductor Homogeneity from Plasma Edge.—D. F. Edwards & P. D. Maker. (*J. appl. Phys.*, Aug. 1962, Vol. 33, No. 8, pp. 2466–2468.) This method based on the position of the plasma edge is an order of magnitude more sensitive than previous ones. A demonstration with an InAs sample is described.

537.311.33 **3739**

Dipole Scattering from Ion Pairs in Compensated Semiconductors.—R. Stratton. (*J. Phys. Chem. Solids*, July 1962, Vol. 23, pp. 1011–1017.) Scattering cross-sections for unscreened and screened dipoles are derived and compared with those for point charges. Electron mobility is calculated for electron scattering by dipoles only, and the combined effects of dipoles, point charges and vibrations are considered.

537.311.33 **3740**

Scattering of Charge Carriers from Point Imperfections in Semiconductors.—T. Morimoto & K. Tani. (*J. phys. Soc. Japan*, July 1962, Vol. 17, No. 7, pp. 1121–1128.) A calculation of the scattering is made using the Born approximation and taking account of strain scattering due to point defects. A considerable interference effect is found between the Coulomb scattering and the scattering due to lattice distortion. This could explain the difference in electron mobilities between Sb-doped and As-doped Ge.

537.311.33 **3741**

Effect of Surface Recombination on the Law of Decrease of Excess Minority Carriers in a Semiconductor.—A. Fortini. (*J. Phys. Rad.*, May 1962, Vol. 23, No. 5, pp. 273–276.) The total number of excess carriers at a given time is computed for optical excitation of a semi-infinite and finite one-dimensional crystal.

537.311.33 **3742**

Space-Charge-Layer Width and Capacitance of Symmetrical Step Junctions.—C. C. Wang. (*Proc. Inst. Radio Engrs*, Aug. 1962, Vol. 50, No. 8, pp. 1838–1839.) For step junctions the inductance effect noted at high forward bias voltages is associated with the drop of quasi-Fermi levels in the neutral regions in which the corresponding carriers are majority carriers.

537.311.33 **3743**

The Dielectric Constant of a Semiconductor as related to the Intrinsic Activation Energy.—C. F. Cole, Jr. (*Proc. Inst. Radio Engrs*, Aug. 1962, Vol. 50, No. 8, p. 1856.)

537.311.33 : 519.4 **3744**

Group Theory and the Energy Band Structure of Semiconductors.—A. Nussbaum. (*Proc. Inst. Radio Engrs*, Aug. 1962, Vol. 50, No. 8, pp. 1762–1781.) The concepts of group theory are explained and applied to the determination of band structure in Te.

537.311.33 : 535.215 **3745**

Observation of Photovoltaic Oscillations in Semiconductors.—L. Gold. (*J. phys. Soc. Japan*, July 1962, Vol. 17, No. 7, p. 1193.) A theory is given to explain oscillations observed by Kikuchi & Abe (2013 of June).

537.311.33 : 535.215 **3746**

Theory of Photoelectric Emission from Semiconductors.—E. O. Kane. (*Phys. Rev.*, 1st July 1962, Vol. 127, No. 1, pp. 131–141.) The variation of yield with energy near threshold is found for a general band structure, and for several production and scattering mechanisms. The distributions of the emitted carriers in energy and direction are also calculated.

537.311.33 : 537.228.1 **3747**

Current Saturation in Piezoelectric Semiconductors.—R. W. Smith. (*Phys. Rev. Lett.*, 1st Aug. 1962, Vol. 9, No. 3, pp. 87–90.) Observations of current saturation in CdS are reported. It is believed to be due to saturation of the shift velocity of electrons.

537.311.33 : 537.312.9 **3748**

Resistance of Elastically Deformed Shallow *p-n* Junctions.—W. Rindner. (*J. appl. Phys.*, Aug. 1962, Vol. 33, No. 8, pp. 2479–2480.) The resistance of diffused and alloyed junctions was found to be highly sensitive to stress under both forward and reverse bias.

537.311.33 : 538.614 **3749**

Oscillatory Interband Faraday Rotation and Voigt Effect in Semiconductors.—Y. Nishina, J. Kolodziejczak & B. Lax.

(*Phys. Rev. Lett.*, 15th July 1962, Vol. 9, No. 2, pp. 55–57.) Results of experiments on thin Ge samples in fields up to 90 kG at room temperature are shown graphically.

537.311.33: 538.614 **3750**

Faraday Effect in Semiconductors.—I. M. Boswarva, R. E. Howard & A. B. Lidiard. (*Proc. roy. Soc. A*, 21st Aug. 1962, Vol. 269, No. 1336, pp. 125–141.) Calculations are carried out on the Faraday rotation in semiconductors due to four kinds of electron transition. The dependence of these on frequency is studied.

537.311.33: 538.63 **3751**

Galvano-thermomagnetic Effects in Degenerate Semiconductors and Semimetals with Nonparabolic Band Shapes: Part 2—General Theory.—T. C. Harman & J. M. Honig. (*J. Phys. Chem. Solids*, July 1962, Vol. 23, pp. 913–922.) A general theory of galvano-thermomagnetic phenomena has been derived for a band with spherically symmetric energy surfaces. The magnitudes of all 560 effects can be predicted from a small number of measurements.

537.311.33: 539.12.04 **3752**

Radiation Effects in Semiconductors.—G. Wertheim. (*Nucleonics*, July 1962, Vol. 20, No. 7, pp. 47–50.) The effects of irradiation are (*a*) ionization, which has a temporary effect, and (*b*) displacements, which cause permanent damage.

537.311.33: [546.28 + 546.289 **3753**

Diffusion of Vacancies during Quenching of Ge and Si.—J. Melngailis & S. O'Hara. (*J. appl. Phys.*, Aug. 1962, Vol. 33, No. 8, pp. 2596–2601.) The concentrations of vacancies trapped in growing Ge and Si dendrites, and in Ge slabs cooled by radiation are calculated. Dislocation loops are unlikely to form in growing dendrites.

537.311.33: [546.28 + 546.289 **3754**

Transport Phenomena in Germanium and Silicon.—G. E. Tauber. (*J. Phys. Chem. Solids*, Jan./Feb. 1962, Vol. 23, pp. 7–18.) Matrix elements are calculated for warped energy surfaces, such as occur in Ge or Si, using the appropriate transition probabilities derived by Ehrenreich & Overhauser (1131 of 1957). The general results are applied to the evaluation of the transport quantities for acoustic and optical scattering.

537.311.33: [546.28 + 546.289 **3755**

Diffusion of Interstitial Impurities in Germanium and Silicon.—R. A. Swalin. (*J. Phys. Chem. Solids*, Jan./Feb. 1962, Vol. 23, pp. 154–156.) Treatment of diffusion relative to the structure of the diamond lattice, and the development of a semi-empirical equation relating the activation energies to properties of the solute.

537.311.33: 546.28 **3756**

Boron-Induced Dislocations in Silicon.—D. P. Miller, J. E. Moore & C. R. Moore. (*J. appl. Phys.*, Aug. 1962, Vol. 33, No. 8, pp. 2648–2652.) Effects of gradual increase in B density in Si are described. At 8×10^{18} atoms cm^{-3}, lattice stress is sufficient to induce edge dislocation generation from loop interaction.

537.311.33: 546.28 **3757**

Diffusion of Phosphorus in Silicon from the Azeotrope of Phosphorus Pentoxide and Water.—R. P. Lothrop. (*J. appl. Phys.*, Aug. 1962, Vol. 33, No. 8, p. 2656.)

537.311.33: 546.28 **3758**

***n*-Type Conversion of Thermally Oxidized Si Surface.**—H. Edagawa, Y. Morita, S. Maekawa & Y. Inuishi. (*J. phys. Soc. Japan*, July 1962, Vol. 17, No. 7, pp. 1190–1191.) Results of measurements on oxidized Si junctions suggest that *n*-type conversion is due to imperfections at the Si-SiO_2 interface or in the bulk of SiO_2 film.

537.311.33: 546.28 **3759**

Resistivity Changes in Quenched *p*-Type Silicon.—W. H. Shepherd. (*J. Phys. Chem. Solids*, Jan./Feb. 1962, Vol. 23, pp. 161–163.) Some observations on the effect described by Kirvalidze & Zhukov (2669 of 1961).

537.311.33: 546.28 **3760**

Field-Effect Measurements on High-Resistivity *p* Type Silicon.—D. Gerlich. (*J. Phys. Chem. Solids*, July 1962, Vol. 23, pp. 837–842.) The distribution of the fast surface states is found to vary with the chemical treatment.

537.311.33: 546.28 **3761**

Changes in Silicon under Intensive Bombardment with 50-keV to 100-keV Electrons.—H. Hora. (*Z. angew. Phys.*, Jan. 1962, Vol. 14, No. 1, pp. 9–12.) A change from *n*- to *p*-type material was observed with a 50-keV beam of intensity 9×10^{16} electrons/cm^2. This is attributed to Frenkel defects caused by surface effects. For results obtained with Si films, see 1608 of May.

537.311.33: 546.28: 535.215 **3762**

Direct and Indirect Excitation Processes in Photoelectric Emission from Silicon.—G. W. Gobeli & F. G. Allen. (*Phys. Rev.*, 1st July 1962, Vol. 127, No. 1, pp. 141–149.) Atomically clean surfaces, with various degrees of sample doping, have been studied. The results indicate volume excitation processes, both direct and indirect, and agree with Kane's theory (3746 above). A direct escape depth for excited electrons is determined.

537.311.33: 546.28: 535.215 **3763**

Work Function, Photoelectric Threshold, and Surface States of Atomically Clean Silicon.—F. G. Allen & G. W. Gobeli. (*Phys. Rev.*, 1st July 1962, Vol. 127, No. 1, pp. 150–158.) The results indicate that the surface atom density and surface state density are almost equal for all available degrees of chemical doping.

537.311.33: 546.28: 621.391.822 **3764**

1/*f* Noise from Vacuum-Cleaned Silicon.—A. U. MacRae. (*J. appl. Phys.*, Aug. 1962, Vol. 33, No. 8, pp. 2570–2572.) Elimination of the slow surface states by surface cleaning in high vacuum did not appreciably affect the observed 1/*f* noise. The noise may be due to some process in the space-charge region.

537.311.33: 546.289 **3765**

Direct Observation of Dislocation Loops in Arsenic-Doped Germanium.—G. E. Brock & C. F. Aliotta. (*IBM J. Res. Develop.*, July 1962, Vol. 6, No. 3, pp. 372–374.) Dislocation loops can be produced easily in *n*-type Ge, the impurity-vacancy interaction being important in their formation. Loop formation does occur during annealing of bulk Ge.

537.311.33: 546.289 **3766**

Behaviour of Germanium in Gallium Arsenide.—L. J. Vieland & T. Seidel. (*J. appl. Phys.*, Aug. 1962, Vol. 33, No. 8, pp. 2414–2415.) "The amphoteric behaviour of Ge in GaAs has been studied quantitatively for small variations in melt composition around the maximum melting point."

537.311.33: 546.289 **3767**

Nuclear Spin-Lattice Relaxation Time in Germanium.—B. J. Wyluda. (*J. Phys. Chem. Solids*, Jan./Feb. 1962, Vol. 23, pp. 63–65.) Measurements were made on *n*-type Ge samples of resistivity from 30 to 0·01 Ω. cm at 295°, 77·2° and 20°K.

537.311.33: 546.289 **3768**

Galvanomagnetic Properties of Grain Boundaries in Germanium Bicrystals from 1·25 to 240°K.—G. Landwehr & P. Handler. (*J. Phys. Chem. Solids*, July 1962, Vol. 23, pp. 891–906.) Hall effect, magnetoresistance and conductivity of wide-angle grain boundaries have been measured.

537.311.33: 546.289 **3769**

Epitaxial Vapour Growth of Single-Crystal Ge.—M. Takabayashi. (*Jap. J. appl. Phys.*, July 1962, Vol. 1, No. 1, pp. 22–29.) Perfect crystals are made by thermal decomposition of GeI_2. The purity is comparable to the best melt-grown Ge.

537.311.33: 546.289 **3770**

Recombination of Electrons and Donors in *n*-Type Germanium: Part 2.—G. Ascarelli & S. Rodriguez. (*Phys. Rev.*, 1st July 1962, Vol. 127, No. 1, pp. 167–169.) The theory indicates that at liquid-He temperatures impact recombination is more important than the alternative mechanism studied (a two-stage transition) for electron concentrations greater than a given value. For lower concentrations the reverse is true. Part 1: 1328 of April.

537.311.33: 546.289 **3771**

Magnetic Susceptibility of Weakly Interacting Donors in Germanium.—D. H. Damon & A. N. Gerritsen. (*Phys. Rev.*, 15th July 1962, Vol. 127, No. 2, pp. 405–413.)

537.311.33: 546.289 **3772**

Surface Storage and Recombination of Carriers in Germanium between 90 and 300°K.—K. H. Beckmann & D. Geist. (*Z. angew. Phys.*, June 1962, Vol. 14, No. 6, pp. 352–358.) The results are analysed of conductivity and lifetime measurements on *n*-type Ge rods of thickness 0·1 and 1·5 mm and subjected to various forms of thermal, mechanical and chemical treatments.

537.311.33: 546.289: 538.569.4 **3773**

Measurements of Relaxation Time in Germanium by the Cyclotron Resonance.—M. Fukai, H. Kawamura, I. Imai & K. Tomishima. (*J. phys. Soc. Japan*, July 1962, Vol. 17, No. 7, pp. 1191–1192.)

537.311.33: 546.289: 539.23 **3774**

Effect of the Temperature of Formation on the Crystallinity and Electrical Properties of Germanium Films on Fluorite.—R. L. Schalla, L. H. Thaller & A. E. Potter, Jr. (*J. appl. Phys.*, Aug. 1962, Vol. 33, No. 8, pp. 2554–2555.)

537.311.33: 546.48-31 **3775**

Semiconductivity and Thermoelectric Power of Cadmium Oxide.—E. F. Lambs & F. C. Tompkins. (*Trans. Faraday Soc.*, July 1962, Vol. 58, No. 7, pp. 1424–1438.) Wright's equations for fully degenerate semiconductors agree well with experimental results, but Wagner's theory of conduction-electron concentration was irreconcilable with measurements at different oxygen pressures.

537.311.33: 546.48'241 **3776**

Behaviour of Gold in Cadmium Telluride Crystals.—I. Teramoto & S. Takayanagi. (*J. phys. Soc. Japan*, July 1962, Vol. 17, No. 7, pp. 1137–1141.) The experimentally determined diffusion coefficient for temperatures above 600°C is $D = 67 \exp(-2 \cdot 0 \text{ eV}/kT) \text{ cm}^2 \text{ sec}^{-1}$. Below 400°C, the observed effects are explained by a model involving the segregation of Au atoms to dislocations.

537.311.33: 546.48'241 **3777**

Phase Equilibria in the System Cd-Te.—M. R. Lorenz. (*J. Phys. Chem. Solids*, July 1962, Vol. 23, pp. 939–947.) The results provide a foundation for a basic investigation of the semiconductor properties of CdTe.

537.311.33: 546.681'18 **3778**

Some Electrical Properties of *p*-Type Gallium Phosphide.—R. J. Cherry & J. W. Allen. (*J. Phys. Chem. Solids*, Jan./Feb. 1962, Vol. 23, pp. 163–165.) Results of Hall-effect and resistivity measurements are discussed.

537.311.33: 546.681'18: 535.376 **3779**

Injection Electroluminescence at *p-n* Junctions in Zinc-Doped Gallium Phosphide.—J. Starkiewicz & J. W. Allen. (*J. Phys. Chem. Solids*, July 1962, Vol. 23, pp. 881–884.) The effect on the spectrum of doping with different amounts of Zn and O_2 is shown and discussed.

537.311.33: 546.681'19 **3780**

Diffusion, Solubility and Electrical Behaviour of Li in GaAs Single Crystals.—C. S. Fuller & K. B. Wolfstirn. (*J. appl. Phys.*, Aug. 1962, Vol. 33, No. 8, pp. 2507–2514.)

537.311.33: 546.681'19 **3781**

Preparation and Characterization of High-Resistivity GaAs.—R. W. Haisty, E. W. Mehal & R. Stratton. (*J. Phys. Chem. Solids*, July 1962, Vol. 23, pp. 829–836.)

537.311.33: 546.681'19 **3782**

Recombination Radiation Emitted by Gallium Arsenide.—R. J. Keyes & T. M. Quist. (*Proc. Inst. Radio Engrs*, Aug. 1962, Vol. 50, No. 8, pp. 1822–1823.) Measurements of emitted radiation intensity on diffused GaAs diodes biased in the forward direction indicate that at 77°K the efficiency in converting injected holes into photons of energy close to the band gap may be as high as 85% for these diodes. Data on spectral distribution and speed of response for this radiation are given.

537.311.33: 546.682'86 **3783**

Indium Antimonide—a Review of its Preparation, Properties and Device Applications.—K. F. Hulme & J. E. Mullin. (*Solid-State Electronics*, July/Aug. 1962, Vol. 5, pp. 211–247.) Aspects of InSb research are covered in which physics, chemistry and metallurgy are involved. 196 references.

537.311.33: 546.682'86: 539.23 **3784**

Annealing Effects in Evaporated InSb Films.—E. B. Dale & G. Senecal. (*J. appl. Phys.*, Aug. 1962, Vol. 33, No. 8, pp. 2526–2530.)

537.311.33: 546.817'241 **3785**

Free-Carrier Absorption in *p*-Type PbTe.—H. R. Riedl. (*Phys. Rev.*, 1st July 1962, Vol. 127, No. 1, pp. 162–166.) Infra-red absorption at 4–28 μ λ was studied at several temperatures in samples with different carrier density. There is additional absorption at intermediate wavelengths, compared with that in *n*-type PbTe.

537.311.33: 546.87'24'22 **3786**

Anisotropy of the Electrical Conductivity and the Seebeck Coefficient of $Bi_8Te_7S_5$.—H. H. Soonpaa. (*J. appl. Phys.*, Aug. 1962, Vol. 33, No. 8, pp. 2542–2546.)

537.311.33: 546.873'241 **3787**

Effects of Heavy Deformation and Annealing on the Electrical Properties of Bi_2Te_3.—J. M. Schultz, J. P. McHugh & W. A. Tiller. (*J. appl. Phys.*, Aug. 1962, Vol. 33, No. 8, pp. 2443–2450.) Deformation causing nonbasal slip in Bi_2Te_3 changes the material from *p*- to *n*-type and reduces its resistivity by forming an excess of negative carriers. Annealing eventually removes the extra carriers and the material becomes *p*-type again. A model is given to account for the observed results.

537.312.62 **3788**

Critical Fields of Thin Superconducting Films: Part 1—Thickness Effects.—A. M. Toxen. (*Phys. Rev.*, 15th July 1962, Vol. 127, No. 2, pp. 382–386.)

537.312.62 **3789**

Critical Field of Thin Superconducting Shapes.—J. J. Hauser & E. Helfand. (*Phys. Rev.*, 15th July 1962, Vol. 127, No. 2, pp. 386–390.)

537.312.62 **3790**

Multiphonon Effects in Tunnelling between Metals and Superconductors.—J. M. Rowell, A. G. Chynoweth & J. C. Phillips. (*Phys. Rev. Lett.*, 15th July 1962, Vol. 9, No. 2, pp. 59–61.)

537.312.62 **3791**

Synthetic High-Field, High-Current Superconductor.—C. P. Bean, M. V. Doyle & A. G. Pincus. (*Phys. Rev. Lett.*, 1st Aug. 1962, Vol. 9, No. 3, pp. 93–94.) A note on the preparation and properties of a filamentary structure made by pressing Hg into porous Vycor glass.

537.312.62 **3792**

Tunnelling into Superconductors.—J. Bardeen. (*Phys. Rev. Lett.*, 15th Aug. 1962, Vol. 9, No. 4, pp. 147–149.) The use and justification of the semiconductor model is discussed in the light of the method of deriving the tunnelling current of Cohen et al. (2743 of August).

537.312.63 **3793**

Phenomenological Theory of Superimposed Films of Normal and Superconducting Metals.—D. H. Douglass, Jr. (*Phys. Rev. Lett.*, 15th Aug. 1962, Vol. 9, No. 4, pp. 155–159.) A modification of Cooper's model (3475 of 1961) is proposed, which removes certain inherent difficulties.

537.323: 546.863'873'241 **3794**

Lattice Parameters in the System Antimony Telluride-Bismuth Telluride.—W. R. Bekebrede & O. J. Guentert. (*J. Phys. Chem. Solids*, July 1962, Vol. 23, pp. 1023–1025.) Lattice spacings and unit cell volumes were found over the complete range of composition.

538.221: 538.569.4 **3795**

Nuclear Magnetic Resonance of Fe^{57} in α-Fe_2O_3.—M. Matsuura, H. Yasuoka, A. Hirai & T. Hashi. (*J. phys. Soc. Japan*, July 1962, Vol. 17, No. 7, pp. 1147–1154.)

538.221: 539.23 **3796**

Shape-Sensitive Uniaxially Magnetized Domains in Ni-Fe Films.—O. W. Muckenhirn, M. H. Monnier & P. J. Besser. (*J. appl. Phys.*, Aug. 1962, Vol. 33, No. 8, pp. 2632–2635.) Properties of shape-sensitive films and factors influencing their production are described. A hypothesis correlating these factors with the film properties is proposed.

538.221: 539.23 **3797**

Domain Structure in Single-Crystal Thin Films of Iron.—Y. Gondō. (*J. Phys. Soc. Japan*, July 1962, Vol. 17, No. 7, pp. 1129–1136.) Observations of the structure of Fe films evaporated on to MgO cleavage surfaces are discussed.

538.221: 539.23 **3798**

The Temperature Dependence of the Magnetization of Very Thin Iron Films.—H. Mayer & D. Stünkel. (*Naturwissenschaften*, June 1962, Vol. 49, No. 12, p. 277.) A note on measurements of saturation magnetization as a function of temperature in the range 180–590°K, on Fe films of thickness 10–120 Å.

538.221: 539.23 **3799**

The Influence of the Manufacturing Conditions on the Magnetic Properties of Electrolytically Produced Permalloy Films.—A. Politycki & H. Gotthard. (*Z. angew. Phys.*, June 1962, Vol. 14, No. 6, pp. 363–365.)

538.221 : 539.23 : 621.318.57 **3800**

Partial-Switching Processes in Thin Magnetic Films.—W. Dietrich. (*IBM J. Res. Develop.*, July 1962, Vol. 6, No. 3, pp. 368–371.) The partial switching which occurs when rapidly rising field pulses with amplitudes just beyond the rotational threshold are applied to the film, is ascribed to inhomogeneities. An unexpected creep effect is also reported.

538.221 : 621.318.12 **3801**

The Stability of Permanent Magnets.—H. Vial. (*Elektrotech. Z., Edn B*, 20th Aug. 1962, Vol. 14, No. 17, pp. 467–468.) The demagnetization of alnico and Ba-ferrite permanent magnets due to temperature fluctuations and external fields can be minimized by a process of artificial aging.

538.221 : 621.318.134 **3802**

Square-Loop Ferrites containing Cadmium.—A. Bragiński, W. Ciastoń, J. Kulikowski & S. Makolagwa. (*Proc. Instn elect. Engrs, Part B*, Sept. 1962, Vol. 109, No. 47, pp. 380–382.) A comparative investigation of Mn ferrites containing Cd and Zn with or without additions of Mg. The preparation of Cd ferrites may be facilitated by applying high oxygen pressure at peak sintering temperature to reduce Cd volatilization.

538.221 : 621.318.134 **3803**

The Inclusion of α-Fe_2O_3 in Mn Ferrite Single Crystals and its Influence on Dislocation Density.—H. Burger & I. Hanke. (*Z. angew. Phys.*, Jan. 1962, Vol. 14, No. 1, pp. 40–43.)

538.221 : 621.318.134 : 538.569.4 **3804**

Observation of Domain-Wall Resonances in Ferrimagnetic Oxides.—E. L. Boyd, J. I. Budnick, L. J. Bruner & R. J. Blume. (*J. appl. Phys.*, Aug. 1962, Vol. 33, No. 8, pp. 2484–2485.)

538.222 : 546.824-31 **3805**

A Study by Static Magnetic Techniques of Rutile Single Crystals after Various External Treatments.—K. G. Srivastava. (*Phys. Lett.*, 1st Sept. 1962, Vol. 2, No. 3, pp. 143–144.) A note on the effects of thermal quenching, electron bombardment and X rays.

539.23 : 546.48'221 **3806**

Rectification and Space-Charge-Limited Currents in CdS Films.—J. Dresner & F. V. Shallcross. (*Solid-State Electronics*, July/Aug. 1962, Vol. 5, pp. 205–210.) The variation of electrical properties with different methods of preparation is discussed.

539.232 **3807**

A Study of the Structure of Evaporated Lithium Fluoride.—D. S. Campbell, D. J. Stirland & H. Blackburn. (*Phil. Mag.*, July 1962, Vol. 7, No. 79, pp. 1099–1116.) A report of an investigation of the effect of different evaporation rates on the initial stages of growth of a nonmetallic material. LiF deposits on carbon are in the form of discrete crystalline islands.

548.0 : 537.311.33 **3808**

Use of Modified Free-Energy Theorems to Predict Equilibrium Growing and Etching Shapes.—R. J. Jaccodine. (*J. appl. Phys.*, Aug. 1962, Vol. 33, No. 8, pp. 2643–2647.) A construction for equilibrium shape of an etching crystal gives results in good agreement with those obtained by experiment.

621.357.7 : 539.23 **3809**

Method for Controlled Multicomponent Sputtering.—W. R. Sinclair & F. G. Peters. (*Rev. sci. Instrum.*, July 1962, Vol. 33, No. 7, pp. 744–746.) A method for sputtering simultaneously from electrically independent electrodes is described.

MATHEMATICS

517.432.1 : 621.317 : 621.372.5 **3810**

The Determination of the Input Function for Linear Systems with Known (Measured) Output Function.—E. G. Woschni. (*Hochfrequenztech. u. Elektroakust.*, June 1962, Vol. 71, No. 3, pp. 110–114.) Application of operational calculus to the problem of determining the true variation of a measured quantity from the output function distorted by the transfer system quadripoles.

517.941 : 621.391.812.63 **3811**

The Nonsingular Embedding of Transition Processes within a More General Framework of Coupled Variables.—Heading. (See 3837.)

MEASUREMENTS AND TEST GEAR

621.3.018.41(083.74) : 621.375.9 : 538.569.4 **3812**

Ammonia Maser on the 3,2 Line as a Frequency Standard: Part 1.—K. Shimoda & N. Kohno. (*Jap. J. appl. Phys.*, July 1962, Vol. 1, No. 1, pp. 5–13.) Frequency stability within a few parts in 10^{11} at 24 Gc/s is reported.

621.3.018.41(083.74) : 621.396.712 **3813**

World-Wide V.L.F. Standard-Frequency and Time-Signal Broadcasting.—A. D. Watt, R. W. Plush, W. W. Brown & A. H. Morgan. (*J. Res. nat. Bur. Stand.*, Nov./Dec. 1961, Vol. 65D, No. 6, pp. 617–627.) Limitations in the stability of received signals are discussed, including path phase distortion, carrier-to-noise and envelope delay variations, with regard to the accuracy of clock synchronization and frequency calibrations.

621.317.3 : 538.632 **3814**

A New Technique for Measuring Hall-Effect Coefficient.—H. Hamer. (*Semiconductor Prod.*, June 1962, Vol. 5, No. 6, pp. 35–36.) A general description of a method which discriminates strongly against ohmic drop and stray induced potentials. An alternating magnetic field and constant current are used.

621.317.331 : 537.311.33 **3815**

Four-Point Probe for Measuring the Resistivity of Small Samples.—J. K. Kennedy. (*Rev. sci. Instrum.*, July 1962, Vol. 33, No. 7, pp. 773–775.) A device is described based on the method originally described by Valdes (1502 of 1954) but modified to be more suitable for small samples.

621.317.335.3 **3816**

A Method of Measuring Static Dielectric Constant Especially of Materials with Long Relaxation Times.—L. N. Clarke. (*Aust. J. appl. Sci.*, June 1962, Vol. 13, No. 2, pp. 81–88.) The method is based on the measurement of charge using a high-gain d.c. amplifier connected as an integrator. The measurement time can be extended to several hours by using the integrator as a null detector of charge. Typical curves of charge and discharge as a function of time are given for four types of capacitor.

621.317.335.3 : 621.372.413 **3817**

Modified Method of Measuring Dielectric Constants.—J. K. Sinha. (*J. Instn Telecommun. Engrs, India*, March 1962, Vol. 8, No. 2, pp. 93–102.) A modification to a method developed by Sinha & Brown (664 of 1961) permits measurements to be made on samples of length $<\lambda/2$.

621.317.337 : 621.372.413 **3818**

A Technique for the Measurement of Q.—J. K. Sinha & S. Sundaram. (*J. Instn Telecommun. Engrs, India*, March 1962, Vol. 8, No. 2, pp. 79–82.) Consistent and reliable measurements of Q-factors of the order of 20 000 have been made on X-band cavity resonators by observation at an i.f. of about 30 Mc/s.

621.317.352.029.6 : 621.372.852.3 **3819**

An Absolute Microwave Attenuator.—P. F. Mariner. (*Proc. Instn elect. Engrs, Part B*, Sept. 1962, Vol. 109, No. 47, pp. 415–419.) The construction and method of operation of a rotary attenuator are described, and the errors that may arise in its use are analysed. Results are given for a 3-cm-λ attenuator which has been compared with a precision piston attenuator operating at 60 Mc/s.

621.317.382 : 538.63 **3820**

Sensitivity of a Magnetoresistance Wattmeter.—S. Kataoka. (*Proc. Inst. Radio Engrs*, Aug. 1962, Vol. 50, No. 8, pp. 1849–1850.) A comparison is made between the magnetoresistance device (1657 of May) and a Hall-effect wattmeter.

621.317.44 **3821**

Highly Sensitive Static Magnetic Field Detector.—D. J. Dumin. (*Proc. Inst. Radio Engrs*, Aug. 1962, Vol. 50, No. 8, p. 1825.) The operation of the detector described is based on the diamagnetic properties of superconductors.

621.317.7 : 535.215 **3822**

Apparatus for Measuring the Temperature Dependence of Photo-Hall Effects in High-Resistivity Photoconductors.—H. E. MacDonald & R. H. Bube. (*Rev. sci. Instrum.*, July 1962, Vol. 33, No. 7, pp. 721–723.) A description of apparatus for the measurement of the Hall effect in illuminated samples with mobility as low as 0·1 cm²/V sec, over the temperature range 77–450° K.

621.317.7: 621.391.822 **3823**

Standard Noise Sources.—P. A. H. Hart. (*Philips tech. Rev.*, 25th July 1962, Vol. 23, No. 10, pp. 293–309.) Resistor, saturated-diode and gas-discharge sources are discussed. The most suitable frequency ranges for each type are considered.

621.317.733.029.64: 538.569.4 **3824**

A Microwave Bridge with Superheterodyne Reception for Electron-Spin-Resonance Measurements in the X Band.—H. Seidel. (*Z. angew. Phys.*, Jan. 1962, Vol. 14, No. 1, pp. 21–22.)

OTHER APPLICATIONS OF RADIO AND ELECTRONICS

621.362: 621.387 **3825**

Extended-Space-Charge Theory in Low-Pressure Thermionic Converters.—R. G. McIntyre. (*J. appl. Phys.*, Aug. 1962, Vol. 33, No. 8, pp. 2485–2489.) An analysis is given of the low-pressure Cs-filled plasma diode.

621.362: 621.387 **3826**

Origin of the Oscillations in a Low-Pressure Thermionic Converter.—P. Mazur. (*J. appl. Phys.*, Aug. 1962, Vol. 33, No. 8, p. 2653.) By integrating the Vlasov equation, it is shown that the stationary states previously believed to be the cause of small current oscillations, do not exist in just that region of the *I*/*V* characteristic where the oscillations are observed.

621.362: 621.387.143 **3827**

The Direct Conversion of Heat into Electrical Energy by means of Rare-Gas-Filled Thermionic Valves.—W. Bloss. (*Z. angew. Phys.*, Jan. 1962, Vol. 14, No. 1, pp. 1–9.) Description of a thermionic converter based on the plasmatron principle [e.g. 1108 of March (Pfender & Bloss)].

621.375.9: 621.372.44: 621.313.13 **3828**

Parametric Machines.—D. J. Hanrahan: H. E. Stockman. (*Proc. Inst. Radio Engrs*, Aug. 1962, Vol. 50, No. 8, pp. 1844–1845.) Comment on 2751 of 1961 and author's reply.

621.385.833 **3829**

An Arrangement for the Magnetization of Objects in Electron Microscopes.—E. Fuchs & W. Liesk. (*Optik, Stuttgart*, June 1962, Vol. 19, No. 6, pp. 307–310.) The method described facilitates the investigation of magnetic structures in the presence of external fields and incorporates a system of automatic compensation for the image movement due to the magnetic field changes.

621.385.833 **3830**

Display Method for the Investigation of Ceramic Surfaces by Electron Microscope.—E. Sterk, M. Tardos & V. Szántó. (*Naturwissenschaften*, June 1962, Vol. 49, No. 12, pp. 277–278.) The method described is suitable for the investigation of the fine structure of ferrite surfaces.

621.385.833 **3831**

The Optimum Resolving Power of the Electron Microscope.—M. L. De. (*Naturwissenschaften*, July 1962, Vol. 49, No. 13, pp. 296–297. In English.) A modified expression for minimum spherical aberration is discussed.

621.385.833 **3832**

Change of the Electron-Microscope Image Contrast at the Transition Amorphous-Crystalline and Liquid-Crystalline.—L. Reimer. (*Naturwissenschaften*, July 1962, Vol. 49, No. 13, pp. 297–298.) Possible applications of the contrast changes are suggested with reference to results obtained with In.

621.387.462: 537.311.33 **3833**

Semiconductor Nuclear Radiation Detectors.—G. Dearnaley. (*J. Brit. Instn Radio Engrs*, Aug. 1962, Vol. 24, No. 2, pp. 153–170.) The mode of operation, methods of preparation and characteristics of various detectors are described, together with the requirements for pulse amplification. 70 references.

PROPAGATION OF WAVES

621.391.812.3 **3834**

Transit-Time Fluctuations of Waves.—R. S. Brown. (*J. atmos. terr. Phys.*, Aug. 1962, Vol. 24, pp. 669–671.) An evaluation of the mean square value of the fluctuation of transit time about the average caused by inhomogeneities of refractive index.

621.391.812.623 **3835**

Obstacle Gain and Shadow Loss.—G. H. Grenier. (*Microwave J.*, July 1962, Vol. 5, No. 7, pp. 60–69.) A practical method of determining path losses to within several db is given, using simple 'knife-edge' analysis as the first approach.

621.391.812.63 **3836**

Study of Radio Wave Propagation in Sweep-Frequency Pulse Transmission Tests in Japan.—Y. Aono. (*J. Radio Res. Labs, Japan*, March 1962, Vol. 9, No. 42, pp. 125–200.) The experimental procedure, observational results and analysis for propagation paths of 1 090 and 1 840 km are given. Vertical-incidence soundings were made simultaneously with the oblique measurements.

621.391.812.63: 517.941 **3837**

The Nonsingular Embedding of Transition Processes within a More General Framework of Coupled Variables.—J. Heading. (*J. Res. nat. Bur. Stand.*, Nov./Dec. 1961, Vol. 65D, No. 6, pp. 595–616.) Mathematical treatment of reflection and coupling processes for plane e.m. waves propagated in an inhomogeneous horizontally stratified anisotropic ionosphere.

621.391.812.63: 551.510.535: 523.75 **3838**

The Effect of a Solar Flare on the Frequency of High-Frequency Ground Back-Scatter.—G. H. Barry & P. R. Widess. (*J. geophys. Res.*, July 1962, Vol. 67, No. 7, pp. 2707–2714.) Fixed-azimuth back-scatter radar equipment operating at 25 Mc/s was used to investigate the ionospheric effects of a Class 2 flare. The observed sudden frequency shift of ground back-scatter is attributed to a rapid change in ionization density in a nondeviative layer 40–100 km thick.

621.391.812.63.029.45/.51 **3839**

Ionospheric Reflection Processes for Long Radio Waves: Part 3.—B. S. Westcott. (*J. atmos. terr. Phys.*, Aug. 1962, Vol. 24, pp. 701–713.) Formulae derived earlier are applied to the case of sech² ionospheric profile, and the results are compared with those previously obtained for an exponential profile. Part 2: 3497 of October.

621.391.812.63.029.45 **3840**

Attenuation Coefficients for Propagation at Very Low Frequencies (V.L.F.) during a Sudden Ionospheric Disturbance (S.I.D.).—E. T. Pierce. (*J. Res. nat. Bur. Stand.*, Nov./Dec. 1961, Vol. 65D, No. 6, pp. 543–546.) Atmospheric-noise records for the frequency range 3·5–50 kc/s are analysed. The onset of s.i.d. conditions has little effect on attenuation between about 12 and 20 kc/s, but causes a decrease in attenuation above this range and a pronounced increase below 12 kc/s. An improved atmospheric noise recorder is proposed which is capable of discriminating between source effects and propagation influences.

621.391.812.63.029.45 **3841**

Magneto-ionic Duct Propagation Time (Whistler Mode) versus Geomagnetic Latitude at 4 kc/s.—C. V. Greenman. (*Proc. Inst. Radio Engrs*, Aug. 1962, Vol. 50, No. 8, p. 1852.) Simplified analysis showing that a graph of the propagation time as a function of geomagnetic latitude of origin may have a flat portion or one of negative slope.

621.391.812.631 **3842**

Very-Low-Frequency Effects from the November 10, 1961, Polar-Cap Absorption Event.—H. F. Bates. (*J. geophys. Res.*, July 1962, Vol. 67, No. 7, pp. 2745–2751.) Changes in amplitude and phase are observed on the polar v.l.f. transmission from Rugby, U.K., to College, Alaska.

621.391.814.2 **3843**

Propagation of Electromagnetic Step Functions over a Conducting Medium.—P. E. Mijnarends. (*J. appl. Phys.*, Aug. 1962, Vol. 33, No. 8, pp. 2556–2564.) "A theoretical treatment is presented of the behaviour of various components of the electromagnetic field generated by a horizontal electric dipole, embedded in a homogeneous conducting half-space, and excited by a step-function current."

RECEPTION

621.396.621: 534.76 **3844**

Simple Decoders (Adaptors) for Use with the F.C.C. Stereo V.H.F. Broad-

casting System.—G. D. Browne. (*Mullard tech. Commun.*, Aug. 1962, Vol. 6, No. 59, pp. 360–367.) Two simple types of decoder operating from the discriminator of a normal f.m. receiver are described in which low- and high-pass filters are avoided. For a similar description see *Wireless World*, Oct. 1962, Vol. 68, No. 10, pp. 487–491.)

621.396.666: 621.396.65 **3845**
A Method of I.F. Switching for a Microwave Diversity System.—D. R. Bester. (*J. Brit. Instn Radio Engrs*, Aug. 1962, Vol. 24, No. 2, pp. 171–179.) High-speed diode switches operating at the i.f. of 70 Mc/s are used.

621.391.8: 621.372.632: 621.372.44 **3846**
Parametric-Converter Performance on a Beyond-the-Horizon Microwave Link.—J. Harvey. (*Elect. Commun.*, 1962, Vol. 37, No. 3, pp. 230–237.) A report of comparative measurements on noise and error rate over a quadruple-diversity link of the White Alice system equipped with two parametric and two normal receivers.

621.391.812.3 **3847**
Distribution of Echo Amplitudes from an Undulating Surface.—J. D. Whitehead. (*J. atmos. terr. Phys.*, Aug. 1962, Vol. 24, pp. 715–721.) The amplitude distribution is calculated for waves reflected at normal incidence from a reflector whose curvature has a Gaussian distribution. Application to s.w. radio communication is briefly discussed.

621.391.82: 551.594.6 **3848**
On the Spectrum of Terrestrial Radio Noise at Extremely Low Frequencies.—H. R. Raemer. (*J. Res. nat. Bur. Stand.*, Nov./Dec. 1961, Vol. 65D, No. 6, pp. 581–593.) A theory of the radio-noise frequency spectrum is presented and the results are compared with those of measurements of the spectrum given in 688 of 1961 (Balser & Wagner). See also 2985 of 1961.

621.391.821 **3849**
Reliability of Atmospheric Radio Noise Predictions.—J. R. Herman. (*J. Res. nat. Bur. Stand.*, Nov./Dec. 1961, Vol. 65D, No. 6, pp. 565–574.) Measured noise values at five frequencies between 0·013 and 10 Mc/s obtained at four measuring stations are compared with C.C.I.R. predictions. Reasons for discrepancies are discussed.

621.391.821 **3850**
Atmospheric Radio Noise Studies based on Amplitude-Probability Measurements at Slough, England, during the International Geophysical Year.—C. Clarke. (*Proc. Instn elect. Engrs*, *Part B*, Sept. 1962, Vol. 109, No. 47, pp. 393–404.) Measurements of amplitude-probability distributions in a power bandwidth of 370 c/s are presented for frequencies of 24 and 135 kc/s, and 11 and 20 Mc/s. Diurnal and seasonal variations of noise power and average value of the noise envelope are derived, and measured values of noise power are compared with C.C.I.R. predictions.

STATIONS AND COMMUNICATION SYSTEMS

621.396.43: 551.507.362.2 **3851**
An Interconnecting Telecommunication Network using Stationary Satellites.—P. Deman & P. Chavance. (*Rev. tech. Comp. franç. Thomson-Houston*, June 1962, No. 36, pp. 7–42.) Specially designed modulation techniques are suggested to simplify the ground stations required.

621.396.65.029.64 **3852**
Research on Radio Relay Systems having a Very High Transmission Capacity (2 700 Telephone Channels or the Equivalent).—F. Carassa. (*Alta Frequenza*, Feb. 1962, Vol. 31, No. 2, pp. 82–95. In English.) Report on design studies and experimental investigations for a telephony and television relay system operating at 6 Gc/s.

621.396.712: 621.3.018.41 (083.74) **3853**
World-Wide V.L.F. Standard-Frequency and Time-Signal Broadcasting.—Watt, Plush, Brown & Morgan. (See 3813.)

621.396.74.029.62(43) **3854**
V.H.F. Transmitters in the German Federal Republic and the Soviet-Occupied Zone.—(*Rundfunktech. Mitt.*, June 1962, Vol. 6, No. 4, pp. 176–179.) Lists and a map of transmitter locations give the position as at 1st April 1962. For similar data on short-wave and long- and medium-wave transmitters see *ibid.*, pp. 180–184.

621.396.97: 534.76 **3855**
Stereophonic Broadcasting Systems.—G. D. Browne. (*Mullard tech. Commun.*, Aug. 1962, Vol. 6, No. 59, pp. 346–359.)
Part 1—The Mullard System (pp. 346–354).
Part 2—The F.C.C. System (pp. 355–359).

SUBSIDIARY APPARATUS

621.314.63 **3856**
Impedance and Rectifying Characteristics of Silicon *p-n* Junctions with Surface Inversion Layer.—O. Jäntsch. (*Solid-State Electronics*, July/Aug. 1962, Vol. 5, pp. 249–259. In German.) Impedance measurements have been made on three rectifiers prepared from *p*-type material of different resistivity. The thickness of the space-charge region and the channel conductivity are determined from the equivalent circuit, and the total surface charge and the surface potential are calculated.

TELEVISION AND PHOTOTELEGRAPHY

621.397.62:621.396.67:621.396.621.22 **3857**
Communal Aerials for Television Reception in Adjacent Channels.—Licht. (See 3576.)

621.397.7(43) **3858**
The Television Networks of the German Federal Republic and the Soviet-Occupied Zone.—(*Rundfunktech. Mitt.*, June 1962, Vol. 6, No. 4, pp. 157–175.) Tabulated data on television transmitters as at 1st April 1962, with maps showing their location and that of television links.

VALVES AND THERMIONICS

621.382: 539.12.04 **3859**
Radiation Effects in Semiconductor Devices.—J. W. Easley. (*Nucleonics*, July 1962, Vol. 20, No. 7, pp. 51–56.) The effects of radiation described in 3752 above alter the characteristics of semiconductor devices. Illustrative examples are given.

621.382: 539.23 **3860**
Current/Voltage Characteristic of Tunnel Junctions.—H. P. Knauss & R. A. Breslow. (*Proc. Inst. Radio Engrs*, Aug. 1962, Vol. 50, No. 8, p. 1834.) Note on a hysteresis effect in the *I/V* characteristics observed in an Al-Al_2O_3-Cu junction at room temperature.

621.382.2 **3861**
The Characteristics of a Semiconductor *p-n* Junction at High Current Densities.—E. Rocher. (*Z. angew. Phys.*, June 1962, Vol. 14, No. 6, pp. 347–352.) The static and dynamic characteristics of a Ge diode are obtained and the results analysed with reference to Stafeev's theory (e.g. 1417 of 1960). At high current levels the forward inductance is suddenly reduced which results in a negative-resistance section of the dynamic characteristic.

621.382.23 **3862**
A Two-Term Analytical Approximation of Tunnel-Diode Static Characteristics.—A. Ferendeci & W. H. Ko. (*Proc. Inst. Radio Engrs*, Aug. 1962, Vol. 50, No. 8, pp. 1852–1853.) A simple two-term exponential approximation is given and its accuracy is determined in comparison with actual characteristics.

621.382.23 **3863**
Simple Method for Calculating the Tunnelling Current of an Esaki Diode.—J. Karlovský. (*Phys. Rev.*, 15th July 1962, Vol. 127, No. 2, p. 419.) Assuming that the distances between the Fermi level and the band edges E_1 and E_2 on both sides of the junction do not exceed $2kT$, the Fermi function is approximated by a straight line.

621.382.23 **3864**
Reversible Degradation Effects in GaSb Tunnel Diodes.—W. N. Carr. (*Solid-State Electronics*, July/Aug. 1962, Vol. 5, pp. 261–263.) Degradation effects are measured and discussed in relation to a theory of diffusion of impurities [*Trans. Inst. Radio Engrs*, Sept. 1961, Vol. ED-8, No. 5, p. 428 (Gold & Weisberg)].

621.382.23 **3865**
InSb Diodes with Normal Barrier Capacitance.—M. T. Minamoto & C. M.

Allen. (*Solid-State Electronics*, July/Aug. 1962, Vol. 5, pp. 263–266.) Results are presented which show better agreement with normal theory than those of Lee & Kaminsky (622 of 1961).

621.382.23 **3866**

Pressure Dependence of the Characteristics of InSb Esaki Diode.—Y. Ōmura & M. Wakatsuki. (*J. phys. Soc. Japan*, July 1962, Vol. 17, No. 7, pp. 1207–1208.) Characteristics of InSb tunnel diodes are measured at hydrostatic pressures up to 11 000 kg cm^{-2}.

621.382.23: 537.533.7 **3867**

Electron-Beam Microanalysis of Germanium Tunnel Diodes.—M. I. Nathan & S. H. Moll. (*IBM J. Res. Developm.*, July 1962, Vol. 6, No. 3, pp. 375–377.) Small regions of solid specimens are excited by a finely focused beam of high-energy electrons. An X-ray spectrometer is used to observe the characteristic emission lines of the atoms in the sample. Results of a quantitative analysis of impurities in tunnel diodes are given.

621.382.23: 539.12.04 **3868**

Neutron Irradiation of Zener Diodes.—J. K. D. Verma. (*J. phys. Soc. Japan*, July 1962, Vol. 17, No. 7, p. 1203.) Irradiation apparently augmented both field emission and avalanche breakdown effects. The changes produced in the diode characteristic are illustrated.

621.382.23: 621.318.57 **3869**

A Broad-Band Ku Crystal-Diode Switch.—K. W. Beck & J. J. Rowley. (*Proc. Inst. Radio Engrs*, Aug. 1962, Vol. 50, No. 8, pp. 1847–1848.) The switch described can operate in the frequency range 12–17 Gc/s with a minimum bandwidth of 2 Gc/s.

621.382.3 **3870**

The Static Characteristics of Transistors.—E. Köhler & H. G. Schulz. (*Nachr-Tech.*, May–July 1962, Vol. 12, Nos. 5–7, pp. 168–172, 218–221 & 266–271.) Summary of the main results of theoretical and experimental investigations of the static characteristics of transistors, including operation outside the normal working range.

621.382.3: 621.317.61 **3871**

The Measurement of the Characteristics of Transistors: Parts 1–3.—R. Paul. (*Nachr Tech.*, May–July 1962, Vol. 12, Nos. 5–7, pp. 163–167, 213–217 & 260–265.) A series of papers reviewing measurement techniques, with numerous references.

621.382.323 **3872**

Thermal Noise in Field-Effect Transistors.—A. van der Ziel. (*Proc. Inst. Radio Engrs*, Aug. 1962, Vol. 50, No. 8, pp. 1808–1812.) The noise figure of field-effect transistors is governed by thermal noise of the conducting channel. Expressions are derived for the equivalent output noise generator and for the equivalent noise resistance of the device.

621.382.323 **3873**

Silicon Field-Effect Transistor with Internal Epitaxial Channel.—G. C. Onodera, W. J. Corrigan & R. M. Warner, Jr. (*Proc. Inst. Radio Engrs*, Aug. 1962, Vol. 50, No. 8, p. 1824.) A technique for the fabrication of field-effect devices is described which meets the requirements of good reproducibility.

621.382.333.3 **3874**

Dynatron-Type Negative Resistance Observed in the Collector-Voltage Saturation Region of the Junction Transistor.—O. Nakahara. (*Jap. J. appl. Phys.*, July 1962, Vol. 1, No. 1, pp. 30–40.) Experimental results are compared with theoretical calculations, assuming appreciable conductivity modulation of the base resistance in the saturation region, and with similar phenomena in field-effect transistors.

621.382.333.4 **3875**

Inductance from a Field-Effect Tetrode.—P. J. Etter & B. L. H. Wilson. (*Proc. Inst. Radio Engrs*, Aug. 1962, Vol. 50, No. 8, pp. 1828–1829.) Bias conditions are proposed for a field-effect tetrode acting as gyrator to simulate an inductance of very high *Q*-value. A suitable design for the gyrator is given.

621.383.292 **3876**

Continuous-Channel Electron Multiplier.—G. W. Goodrich & W. C. Wiley. (*Rev. sci. Instrum.*, July 1962, Vol. 33, No. 7, pp. 761–762.) Electron multiplication by secondary emission is achieved in small tubular dynodes and used to amplify very weak currents.

621.383.42: 621.311.69 **3877**

The Efficiency of Selenium Photocells at Low Illumination Levels.—W. Dürr. (*Z. angew. Phys.*, Feb. 1962, Vol. 14, No. 2, pp. 88–91.) Comparative measurements of efficiency for sunlight and for monochromatic light of $\lambda = 577$ mμ on Se and Si photocells.

621.383.5 **3878**

Storage of Photoelectric Signals in *n-p* Junctions.—G. A. Boutry, F. Desvignes & M. Robert. (*J. Phys. Rad.*, April 1962, Vol. 23, No. 4, pp. 262–264.) A theoretical and experimental note on biasing effects at low temperature with application to the observation of extremely weak photoelectric signals ($\approx 10^{14}$A) and the realization of an infrared scanning tube.

621.383.5 **3879**

Silicon Surface-Barrier Photocells.—E. Ahlstrom & W. W. Gärtner. (*J. appl. Phys.*, Aug. 1962, Vol. 3, No. 8, pp. 2602–2606.) Data are given on photocurrent as a function of light intensity, reverse-bias voltage and temperature, and on open-circuit photovoltage as a function of light intensity, wavelength and temperature.

621.383.52 **3880**

A High-Speed Point-Contact Photodiode.—L. U. Kibler. (*Proc. Inst. Radio Engrs*, Aug. 1962, Vol. 50, No. 8, pp. 1834–1835.) Brief description of a Ge *p-i-n* junction photodetector suitable for wide-band operation at frequencies up to 50 Gc/s. Tests were carried out with a He-Ne gas maser.

621.383.52: 621.391.64 **3881**

New Infrared-Generating Diode Transmits Television over Modulated Light Ray.—T. Maguire. (*Electronics*, 27th July 1962, Vol. 35, No. 30, pp. 24–25.) Zn-diffused GaAs diodes can be used to transmit television signals, although the output is not coherent.

621.385.032.212.3 **3882**

The Construction of a Stable Field Cathode.—Z. Hájek & L. Eckertová. (*Naturwissenschaften*, May 1962, Vol. 49, No. 9, p. 201.) Stable currents and repeatable results were achieved with cold cathodes of the type Al-Al_2O_3-metal (e.g. Ag, Au, Pt). The requisite conditions for such operation are summarized and advantages over the porous type of cathode [e.g. 350 of 1960 (Skellett et al.)] are mentioned.

621.385.032.213.13 **3883**

The Space-Charge-Neutralized Hollow Cathode.—A. L. Eichenbaum. (*RCA Rev.*, June 1962, Vol. 23, No. 2, pp. 230–245.) Cs vapour in an electron-emissive cylinder can be used to produce either electron beams of high current density at moderate temperatures or beams of moderate density at low temperatures.

621.385.032.213.23 **3884**

Role of Carburization in the Suppression of Emission from Barium-Activated Tungsten and Molybdenum Surfaces.—E. S. Rittner & R. Levi. (*J. appl. Phys.*, July 1962, Vol. 33, No. 7, pp. 2336–2340.) Emission inhibition due to carburization [see 3977 of 1961 (Levi & Rittner)] results from greatly reduced activator coverage of the surface of the carbide relative to that of the metal, because of much weaker adsorption forces.

621.385.032.213.23 **3885**

Field-Emission Studies on Kinetics of Barium Oxide on Tungsten.—K. Noga. (*J. phys. Soc. Japan*, June 1962, Vol. 17, No. 6, pp. 950–961.) Studies of the absorption of BaO on W are reported. The mean dipole moment of the adsorbed molecule is estimated. At temperatures above 800°C the oxide reacts chemically with W with an activation energy of approximately 3·3 eV.

621.385.2: 537.24 **3886**

Microparticles Diodes.—C. Maisonnier & M. Haegi. (*J. appl. Phys.*, Aug. 1962, Vol. 33, No. 8, pp. 2474–2478.) The motion of a group of small conducting spheres located between two parallel plates is investigated theoretically for space-charge-limited flow and a more realistic model is proposed. Experimental apparatus used to check theoretical predictions is described.

621.385.2.029.6 **3887**

Measurements of the Freqnency Dependence of the Admittance of Plane-Parallel Space-Charge Diodes in the Transit-Time Region.—F. Seifert. (*Nachrichtentech. Z.*, June 1962, Vol. 15, No. 6, pp. 263–266.) Measurements are carried out at frequencies in the range 300–600 Mc/s on modified disk-seal diodes with cathode/anode spacings of 1·45 and 2 mm.

621.385.3.012 : 681.142 **3888**

The Calculation of Accurate Triode Characteristics using a Modern High

Speed Computer.—O. H. Schede, Sr. (*RCA Rev.*, June 1962, Vol. 23, No. 2, pp. 246–284.) The classical space-current solution is shown to be inadequate for modern close-spaced thermionic valves. A computer is programmed to calculate complete *I/V* characteristics from basic input data, with corrections for space-charge effects and initial electron velocities.

621.385.6 **3889**

Electrokinetic Vortex Beams.—H. W. König. (*Arch. elekt. Übertragung*, June 1962, Vol. 16, No. 6, pp. 271–282.) The characteristics of vortex beams are derived theoretically with particular emphasis on energy relations. See also 1099 of March (Riedler).

621.385.6: 537.533 **3890**

Axial Quasi-Brillouin Streams.—M. H. Miller. (*J. appl. Phys.*, July 1962, Vol. 33, No. 7, pp. 2247–2248.) "A non-laminar model for axially uniform electron streams is postulated and conditions for which the model is consistent with physical requirements are derived. The character of the current density profiles permitted by the model are discussed." For analysis of rectilinear flow see 330 of January.

621.385.6: 621.391.822 **3891**

Some Results from the Measurements of the Noise Parameters in Electron Beam.—S. Saito & Y. Fujii. (*Proc. Inst. Radio Engrs*, July 1962, Vol. 50, No. 7, pp. 1706–1707.) Description of the experimental determination of these parameters by a direct method of measurement [1067 of 1960 (Saito)].

621.385.6.032.269.1 **3892**

Electron Guns for Forming Solid Beams of High Perveance and High Convergence.—R. D. Frost, O. T. Purl & H. R. Johnson. (*Proc. Inst. Radio Engrs*, Aug. 1962, Vol. 50, No. 8, pp. 1800–1807.) Two methods of design are described and data are given of three types of electron gun developed by these techniques.

621.385.62: 537.13 **3893**

A 5-Mc/s Klystron Amplifier using Positive Ions.—M. R. Gavin, K. Chandra & L. J. Lloyd. (*Nature, Lond.*, 8th Sept. 1962, Vol. 195, No. 4845, p. 988.) Certain experimental difficulties encountered in investigating design principles of microwave klystrons are avoided by substituting positive ions for electrons and operating at a much lower frequency.

621.385.623.2 **3894**

Optimum R.F. Field Distribution of Monotron Cavities.—K. Blotekjaer & B. Grung. (*J. Electronics Control*, June 1962, Vol. 12, No. 6, pp. 441–459.) Mathematical analysis relating to the design of monotron oscillators for maximum negative small-signal electronic conductance. The optimum field distribution is shown in a number of graphs for various d.c. gap transit angles and space-charge densities.

621.385.623.2 **3895**

Optimization of R.F. Voltage Amplitudes and Gap Spacing of Generalized Floating-Drift-Tube Oscillators.—K. Blotekjaer. (*J. Electronics Control*, June 1962, Vol. 12, No. 6, pp. 461–499.) A detailed analysis of a monotron oscillator with an interaction region comprising a number of narrow gaps separated by drift tubes. The conditions for maximum conversion efficiency are determined.

621.385.624 **3896**

Klystron Frequency Multipliers: Effect of D.C. Velocity Spread on Performance.—L. Solymar & P. V. Schefer. (*Electronic Technol.*, Sept. 1962, Vol. 39, No. 9, pp. 362–364.) A theoretical treatment is given based on large-signal ballistic theory applied to a model consisting of two discrete electron beams.

621.385.63 **3897**

The Beam Maser—a Unique Depressed Collector for Crossed-Field Travelling-Wave Tubes.—J. M. Osepchuk. (*Microwave J.*, July 1962, Vol. 5, No. 7, pp. 75–78.) A 30% increase in the power output of standard M-type backward-wave oscillators has been achieved by the addition of a collector internally connected to the cathode so as to reduce the anode current for a given beam current.

621.385.63 **3898**

Power Carried by the Helitron Waves on an E-Type Filamentary Electron Beam.—I. Sakuraba. (*Proc. Inst. Radio Engrs*, Aug. 1962, Vol. 50, No. 8, p. 1839.)

621.385.63: 621.375.9: 621.372.44 **3899**

Partition Effects in Transverse Electron-Beam Waves.—P. A. H. Hart. (*J. appl. Phys.*, Aug. 1962, Vol. 33, No. 8, pp. 2401–2408.) Theory is presented concerning the attenuation of the original beam waves, the fast, the slow, and two synchronous waves, and the generation of noise waves if part of the beam is intercepted. See also 1833 of 1960 (Siegman).

621.385.63: 621.375.9: 621.372.44 **3900**

Transverse Electron-Beam Noise Described by Filamentary Beam Parameters.—K. Blotekjaer. (*J. appl. Phys.*, Aug. 1962, Vol. 33, No. 8, pp. 2409–2414.) The equivalence of the physical noisy beam and the theoretically equivalent modulated filamentary beam is demonstrated. The frequency components of the equivalent filamentary beam modulation are calculated.

621.385.63 : 621.375.9: 621.372.44 **3901**

Graphical Expressions of Synchronous Conditions in the Transverse-Type Electron-Beam Parametric Amplifier.—K. Kakizaki. (*Proc. Inst. Radio Engrs*, Aug. 1962, Vol. 50, No. 8, pp. 1850–1851.)

621.385.64 **3902**

Electron Trajectories in a Magnetron.—C. G. Lehr, J. W. Lotus, I. Silberman & R. C. Gunther. (*J. Electronics Control*, Aug. 1962, Vol. 13, No. 2, pp. 89–122.) The problem of electron trajectories in an oscillating magnetron was investigated by numerical analysis using Hartree's method of self-consistent fields. The trajectories so obtained do not converge to a self-consistent result until the requirement of space-charge-limited cathode emission is dropped.

621.385.832 **3903**

Charging Processes due to Returning Secondary Electrons in Homogeneous Storage Layers of Charge Storage Tubes.—W. Harth. (*Z. angew. Phys.*, Jan. 1962, Vol. 14, No. 1, pp. 12–20.) Investigation of the charging mechanism using a double-beam storage tube with a mesh-type collector grid at a variable distance from the storage target. The effect on the resolving power of storage tubes is discussed.

621.385.832 **3904**

The Deflection Errors of Cylindrical Electrostatic Simultaneous Deflection Systems.—F. Schäff, W. Harth & W. Dommaschk. (*Z. angew. Phys.*, Aug. 1962, Vol. 14, No. 8, pp. 507–512.) The deflection characteristics and aberrations of a cylindrical 'deflectron' system [see e.g. 2591 of 1956 (Schlesinger)] are calculated.

621.387: 621.362 **3905**

Extended-Space-Charge Theory in Low-Pressure Thermionic Converters.—McIntyre. (See 3825.)

621.387: 621.362 **3906**

Origin of the Oscillations in a Low-Pressure Thermionic Converter.—Mazur. (See 3826.)

621.387.143: 621.362 **3907**

The Direct Conversion of Heat into Electrical Energy by means of Rare-Gas-Filled Thermionic Valves.—Bloss. (See 3827.)

MISCELLANEOUS

621.39: 061.4 **3908**

National Radio Show Review.—(*Wireless World*, Oct. 1962, Vol. 68, No. 10, pp. 475–482.) An analysis of design trends with reference to equipment seen at the exhibition at Earls Court, London, 22nd August–1st September, 1962.

621.396: [523 + 55 **3909**

Space Research and Telecommunications.—(*Tech. Mitt. PTT*, Aug. 1962, Vol. 40, No. 8, pp. 250–286.) The text is given of the following papers presented at a convention held in Basle on 17th November 1961:

(*a*) Space Research.—M. Golay (pp. 251–257. In French).

(*b*) Plasma Physics.—F. Lüdi (pp. 257–268. In German).

(*c*) Maser and Laser: their Physical Principles and Possible Applications.—B. Elschner (pp. 268–273. In German).

(*d*) Telecommunications with the Aid of Artificial Earth Satellites.—W. Klein (pp. 273–286. In German).

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contents

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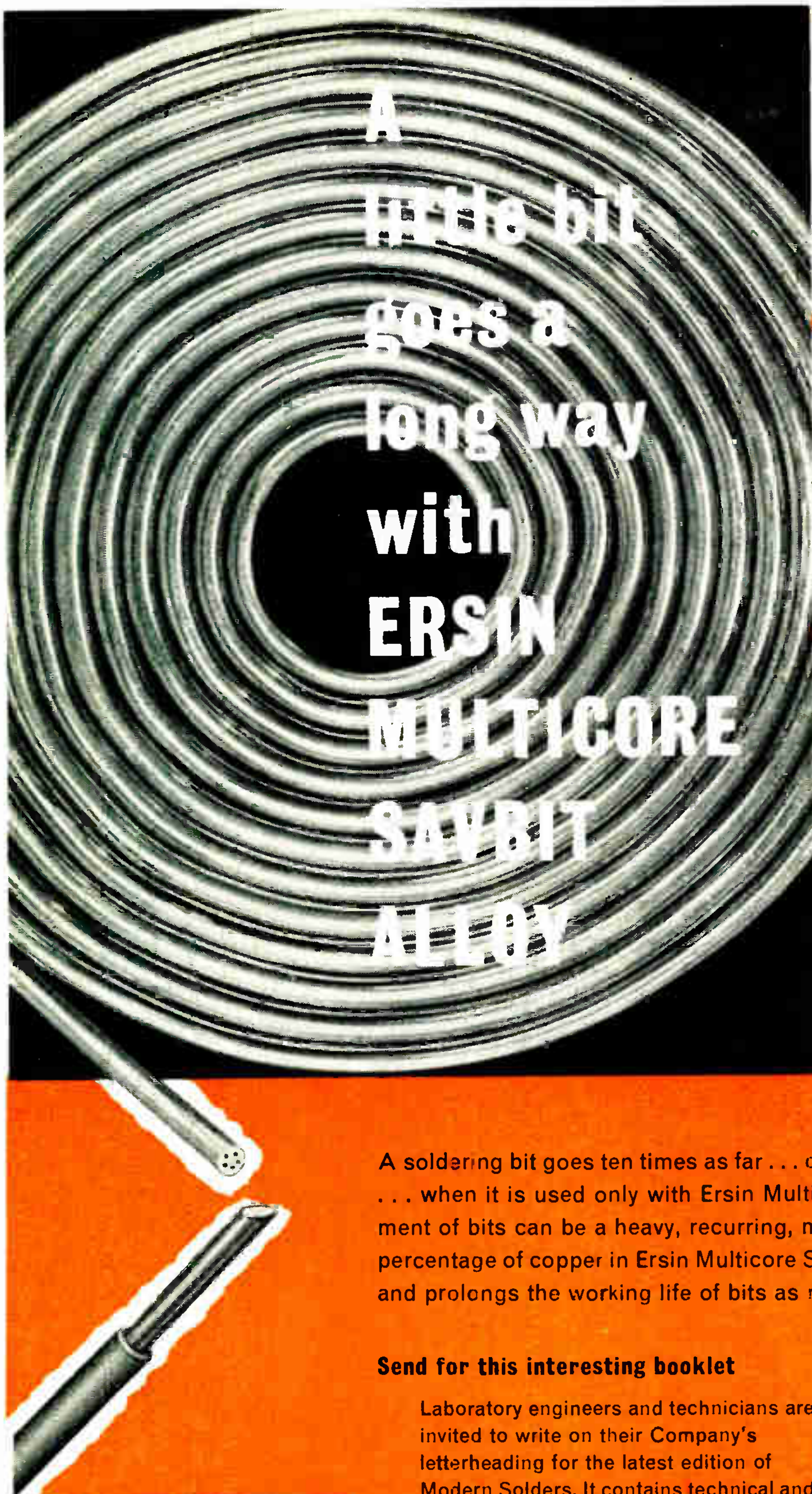

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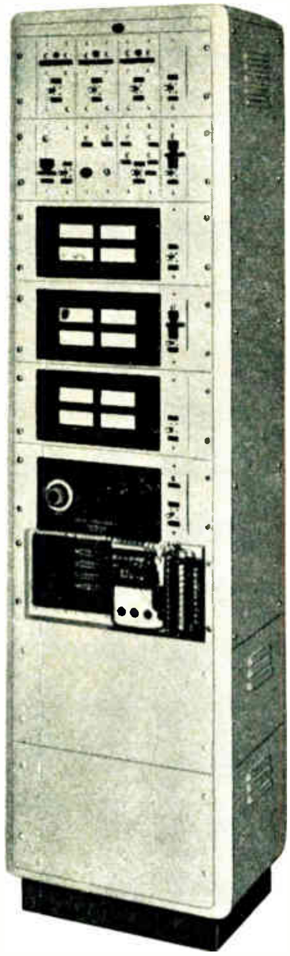

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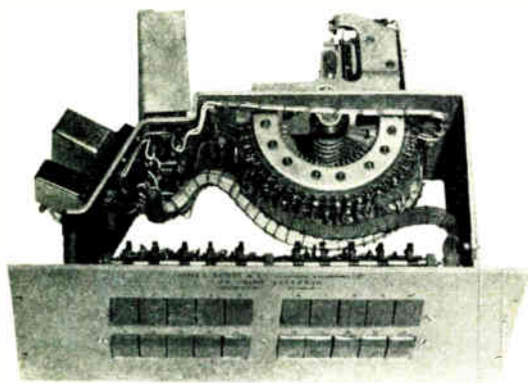

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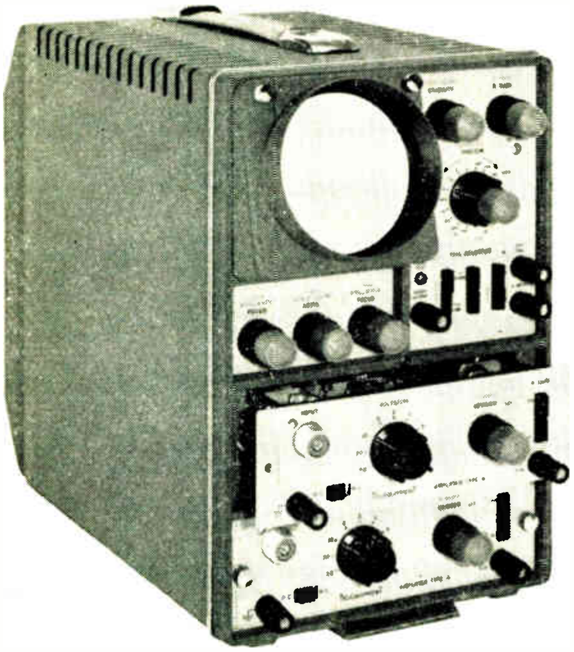

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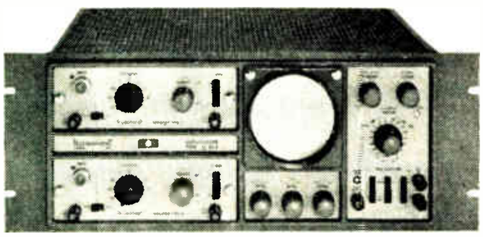

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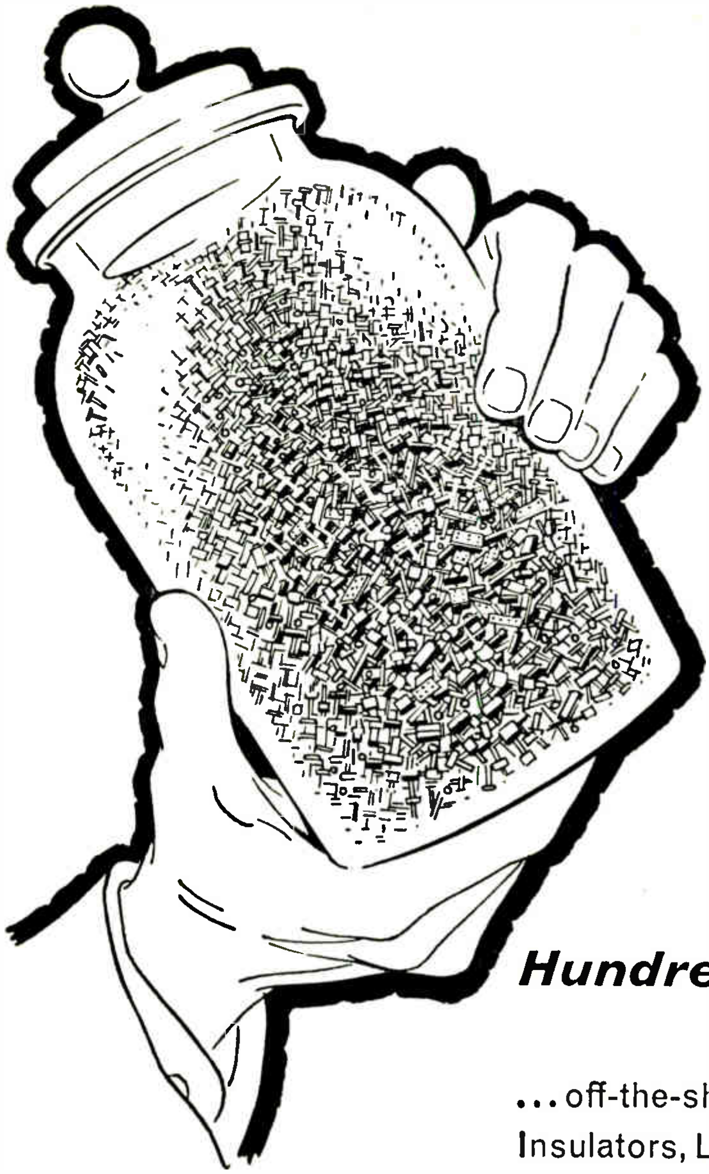

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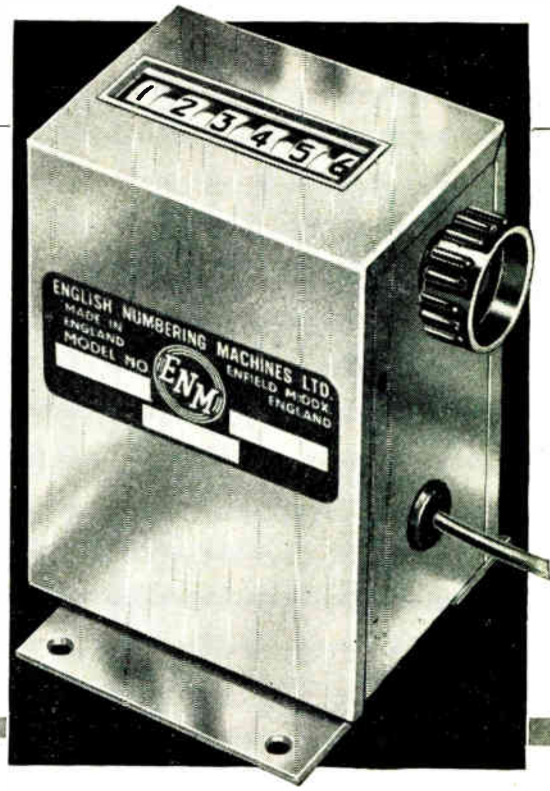

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34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51
52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69
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232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249
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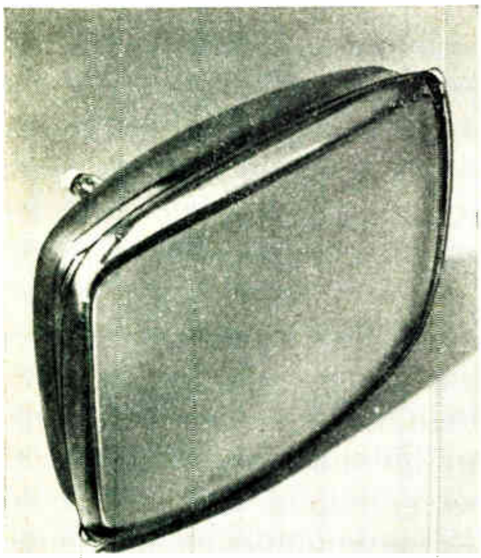
MAZDA ALL GLASS twin panel tubes



110° 19" and 23" twin panel

SHORT TELEVISION TUBES

CME 1906/A47-13W
CME 2306/A59-13W

The CME1906 and CME2306 are respectively 19in. and 23in. twin panel cathode-ray tubes. They differ from previous 19in. and 23in. tubes of the Mazda range in that each has a moulded safety panel of tinted glass bonded directly to the front face of the tube. In neck length and electrical characteristics these tubes are identical to CME1903 and CME2303 respectively, having 110° deflection angle and using magnetic deflection and electrostatic focus.

GENERAL DETAILS

Twin Panel	Tinted Grey Glass
Rectangular Face	110° Deflection Angle
Aluminised Screen	Silver Activated Phosphor
Electrostatic Focus	Magnetic Deflection
Short Neck	Straight Gun—non ion trap

External Conductive Coating
Heater for use in Series Chain
Heater Current I_h 0.3 A
Heater Voltage V_h 6.3 V

DESIGN CENTRE RATINGS

	CME1906	CME2306	
Maximum Second and Fourth Anode Voltage $V_{a2,a4(max)}$	17	17	kV
Minimum Second and Fourth Anode Voltage $V_{a2,a4(min)}$	13	13	kV
Maximum Third Anode Voltage $V_{a3(max)}$	+1 to −0.5	+1 to −0.5	kV
Maximum First Anode Voltage $V_{a1(max)}$	550	550	V
Maximum Heater to Cathode Voltage-Heater Negative (d.c.) $V_{h\text{-}k(max)}$	200	200	V

INTER-ELECTRODE CAPACITANCES

Cathode to All* $c_{k\text{-}all}$	3.5	3.5	pF
Grid to All* $c_{g\text{-}all}$	8.5	8.5	pF
Final Anode to External Conductive Coating (approx.) $c_{a2,a4\text{-}M}$	1250	2000	pF

* Including AEI B8H Holder VH68/81 (8 pin)

TYPICAL OPERATION

Grid Modulation (Voltages referred to cathode)

Second and Fourth Anode Voltage $V_{a2,a4}$	16	16 to 17	kV
First Anode Voltage V_{a1}	400	400	V
Beam Current	350	350	µA
Third Anode Voltage for Focus (Mean) $V_{a3(av)}$	200	200	V
Average Peak to Peak Modulating Voltage	35.5	35.5	V
Grid Bias for Cut-off of Raster V_g	−40 to −77	−40 to −77	V

MAXIMUM DIMENSIONS

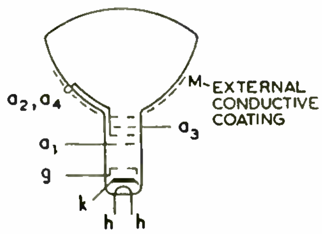
Overall Length	317	374	mm
Face Diagonal	491†	614‡	mm
Face Width	441	544	mm
Face Height	361	443	mm
Neck Diameter	29.4	29.4	mm

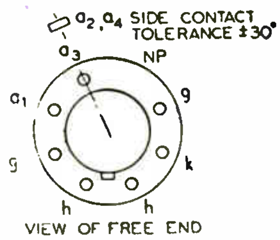
† The maximum dimension over the complete panel is 507 mm
‡ The maximum dimension over the complete panel is 631 mm

TUBE WEIGHT

Nett (Approx)	22.5	37.5	lbs.

Side Contact: CT8 (Cavity) **Base:** B8H





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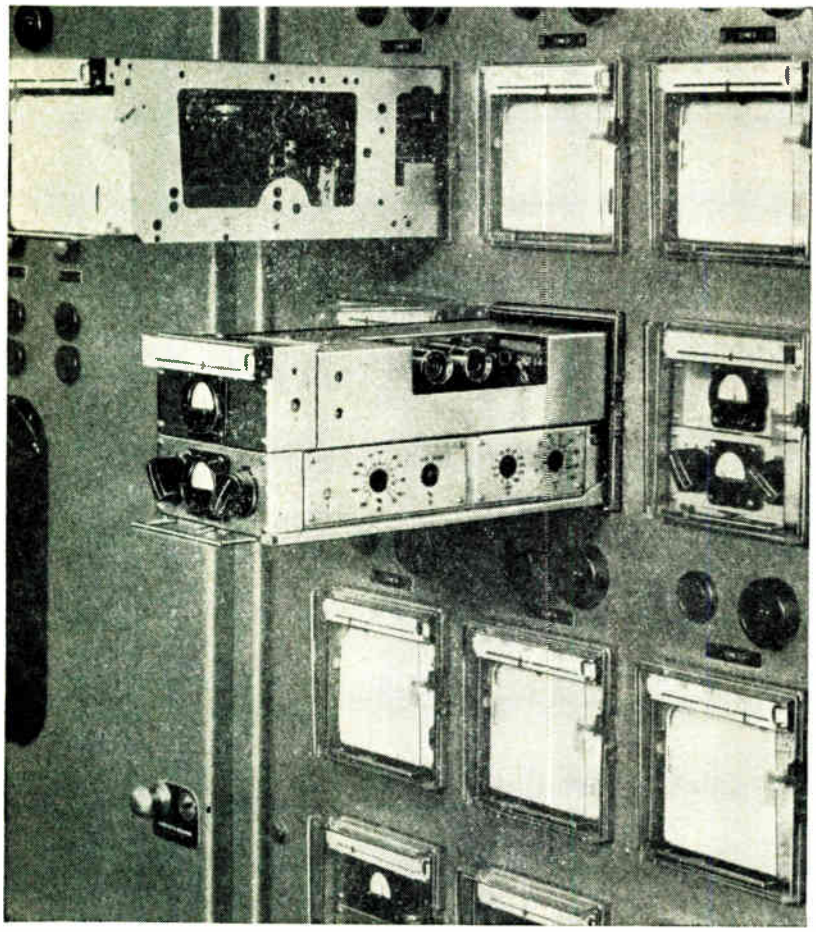

Philips Three-Term Controllers and Miniature Recorders in a process control panel at a ceramic works.

SPECIFICATION

Input Signal 0........ 8 volts DC; 2.........10 volts DC; 0.........5 mA DC; 0.........20 mA DC 0.........50 mA DC; 1.........5 mA DC; 4.........20 mA DC; 10........ 50 mA Dc.

Input Load Depends on input signal; maximum input load 5000 ohms.

Accuracy of Input Deviation Meter ± 5% of measuring range.

Output Signal For standard version 1........ 5 mA DC direct or reverse acting.

Output Load For standard version 3000 ohms.

Accuracy of Output Meter ± 5% of output range.

Set Point Setting accurate within ± 0.5% of set point range.

P-action 3.........300% continuously adjustable.

I-action 2.........1800 seconds in 20 logarithmic steps. Also infinite reset time (i.e. no integral action).

D-action 2.........600 seconds in 11 logarithmic steps. Also zero rate time (i.e. no derivative action). At higher frequencies D-action does not exceed 10 x P-action (tame derivative).

Zero Frequency Gain Higher than 200 at 100% P-action setting (i.e. Initial Proportional Band under ½%).

Max. Output Current (output terminals short circuited) 12 mA DC.

Maximum Output Voltage at Infinite Output Load 16 volts DC.

Manual Automatic Switching Bumpless transfer: manual to automatic direct, automatic to manual via balance position.

Power Supply 110-240 volts AC ± 10%, 40.........60 c/s, 30 VA.

Maximum Permissible Ambient Temperature 45°C (113°F).

Net Weight 15 kg (33 lbs.).

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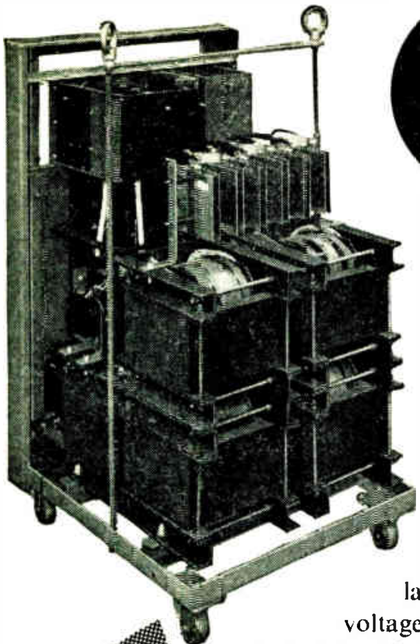

HED

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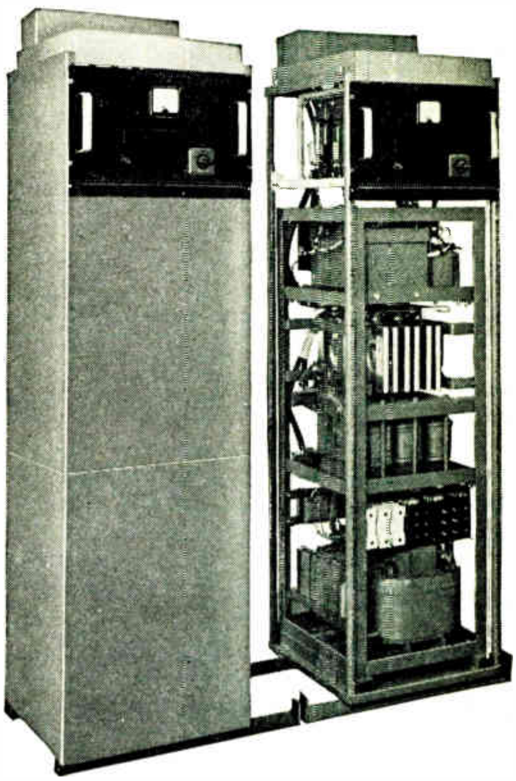

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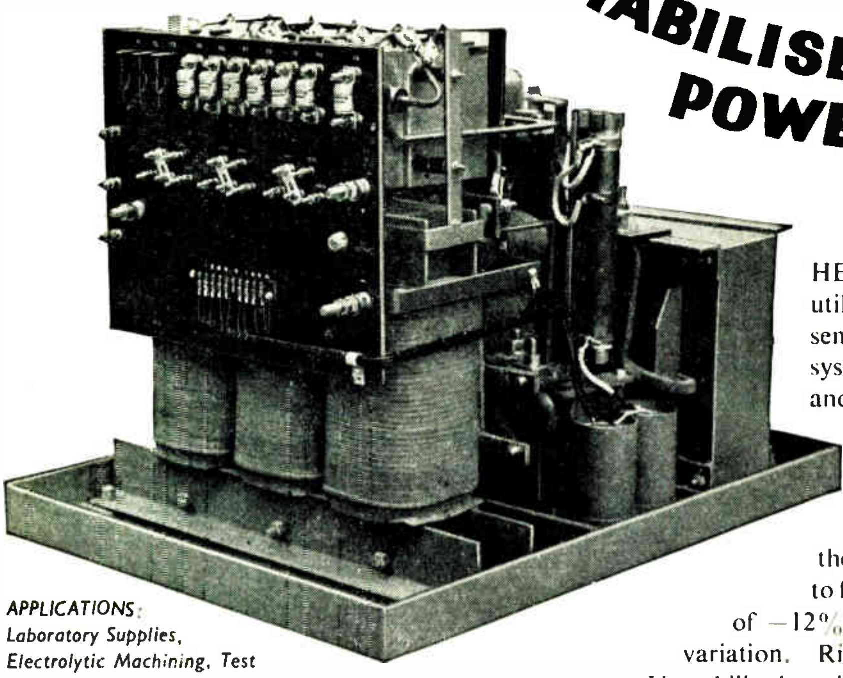
Regulation is achieved by standard HED transistorised amplifier and reference units in conjunction with saturable reactors.
The highest degree of reliability is ensured by the use of these static devices.

APPLICATIONS : Furnace Control, Arc Welding Control, Light Dimming, Motor Speed Control, etc.

STABILISED RECTIFIER POWER PACKS



HED Stabilised Rectifier Power Packs utilise a saturable reactor, transformer, semi-conductor amplifiers and reference system, the A.C. output being rectified and smoothed to give a D.C. output.
High speed response and high accuracy is a major feature of this system. Both single or three phase inputs can be utilised up to 300 KW, the regulation being ±1% from no load to full load with mains voltage variations of −12% to +6%, and with ±2% frequency variation. Ripple is 4% or to specification.
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APPLICATIONS: Laboratory Supplies, Electrolytic Machining, Test Supplies, Aircraft Supplies, Linear Accelerator Magnet Supplies, Motor Speed Control Supplies, etc.

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point-contact general purpose diodes

HG10

High forward conductance
Max. average power dissipation 80mW
Nominal capacitance at -10V 0.2pF
Operating and Storage temperature range -60°C to 90°C

Type	P.I.V.	Max. D.C. or Mean Forward Current (mA at 25°C)	Min. Forward Current at 1V (mA)	Max. Reverse Current at —50V (μA at 25°C)
*HG1005	100	45	5	50
†HG1006	100	45	5	100
HG1012	75	45	5	100

TYPE APPROVED *CV 7041 †CV 448 & †CV 7130

gold-bonded computer diodes

HG50

Extremely high forward conductance
Stored charge at 10mA 400pC
Nominal capacitance at -10V 0.4pF
Max. average power dissipation 80mW

TYPE APPROVED *CV 7127

Type	Min. Breakdown Voltage	Max. D.C. or Mean Forward Current (mA @ 25°C)	Max. Forward Voltage at 100mA	Max. Reverse Current at 25°C μA	@ V
HG5003	100	100	0.8	25	-50
*HG5004	70	100	0.8	25	-50
HG5008	40	100	0.8	25	-30
HG5085	Transistor base protection diode	V_f at 100 mA (25°C) ....1.0V max. I_b at -1.0V (45°C) ....5μA max. P.I.V. ....5V Max. DC Current (25°C) ....100 mA			

fast recovery computer diodes

HD18

High forward conductance
6 Nanosec typical recovery time
Nominal capacitance at -1V 1.5pF

Type	P.I.V.	Max. Forward Voltage @ 10 mA	Max. Forward Voltage @ 100 mA	Max. Reverse Current @ -10V (25°C)
HD1810	50	0.45	0.75	5μA
HD1840	30	0.45	0.70	10μA
HD1841	20	0.45	0.70	20μA
HD1870	15	0.42	0.70	15μA
HD1871	10	0.42	0.70	20μA (@ -5v)

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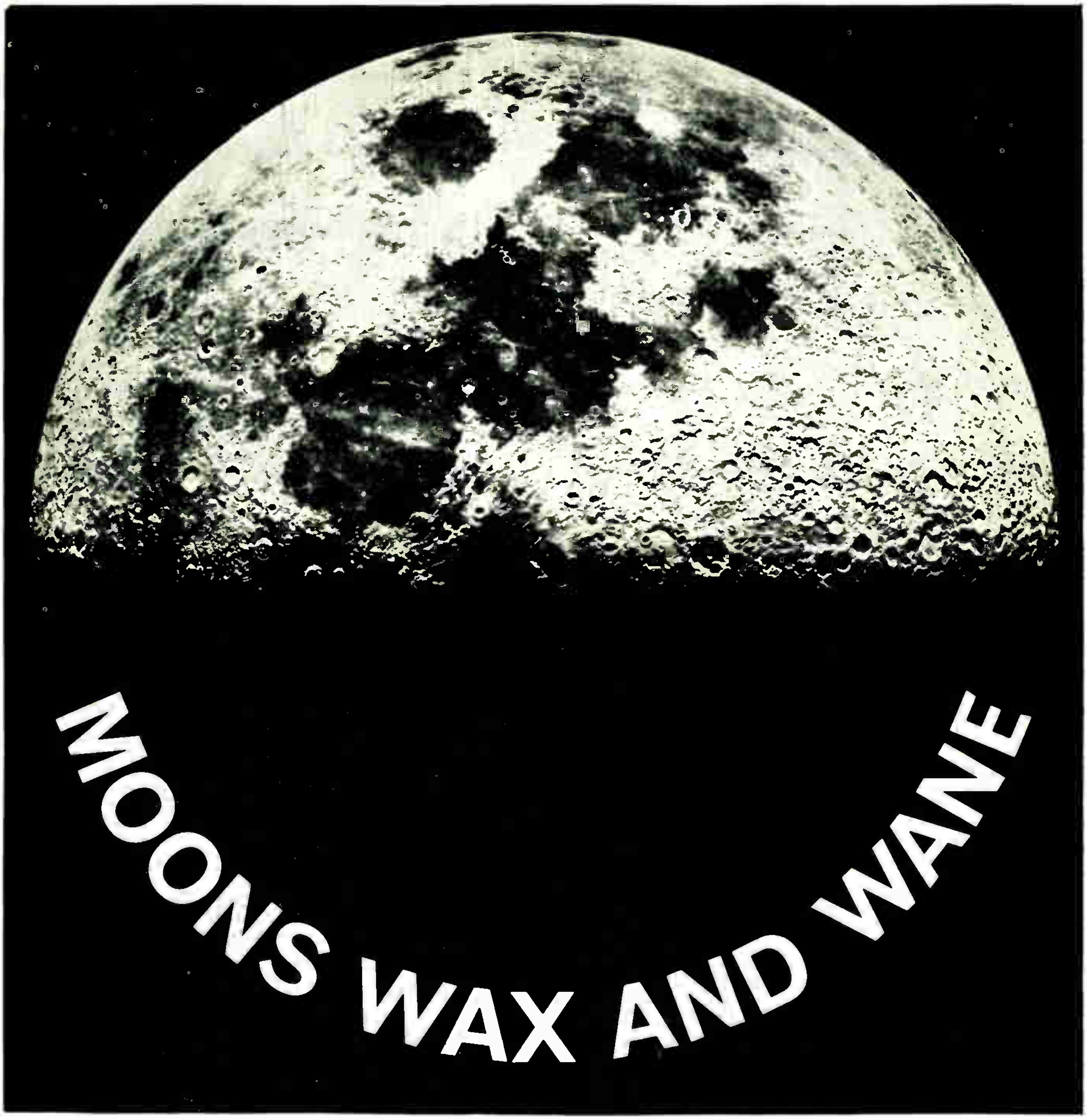

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INDUSTRIAL ELECTRONICS

Comment

It is now fashionable to talk about learning machines, by which is meant machines which can be taught to perform desired functions. Elsewhere in this issue some of their elementary principles are discussed. Such machines in any useful form still lie very much in the future, but the idea of the learning machine has captured people's imagination.

However, we seriously wonder if 'learning' is the right word. It seems to us that the idea of learning necessarily implies the idea of consciousness, and no one has suggested that the machine has this. According to the dictionary, learning means the acquisition of knowledge or skill by study.

We suggest that these machines would more properly be called trainable machines. Training involves bringing to a desired state by instruction and practice. This is just what is done with these machines and the word does not involve such personal associations as 'learning'.

We ourselves think it desirable to avoid the use of personality labels for machines. We do not believe that electronic brains are brains, nor that computer memories are memories. We could at this point bring in an obvious quotation from Shakespeare. Instead, we will refer to B.S. 2641: 1955 which deprecates 'memory' and says that the proper word is 'store'.

Road Accidents

There has so far been no widespread use of electronics to help in reducing road accidents. Closed-circuit television has found some application for traffic control in cities, and there are reports of experimental work, especially in the U.S.A., on the automatic control of vehicles. This includes most elaborate systems in which the speed and even steering of a car is taken completely out of the driver's control. They involve not only elaborate apparatus on the vehicle itself, but an elaborate system of buried guidance cables in the road. We suspect that it might be simpler to lay rails and turn cars into trams!

Without going to such lengths, electronics could help in road safety. It is technically possible for it to do so. A prevalent driving fault, which is responsible for many of the multiple car crashes, is following too closely behind another vehicle. It would not be difficult to prevent this with the aid of electronic apparatus.

A radar-like device, probably using ultrasonics, could be mounted in the front of a car and would produce an output proportional to the distance from the car in front. A simple logic unit fed with this signal and with one from the car's speedometer could produce a control output which would act, first, to close the throttle and then, if necessary, to apply the brakes if the speed of the car exceeded the proper value for its distance from another car.

We doubt if many drivers would like the device, however, and few would be willing to pay for it, for it would not be cheap. We suspect that more people would be willing to fit it if it were used not to control one's own car but were turned round and used to display a large notice at the back to tell a following driver that he is too close!

Transatlantic Communication

The Post Office has a permanent exhibition of telecommunications equipment in Fleet Building, Farringdon Street, London, E.C.4, which is open to the public. It now includes a model of an orbiting satellite with a tracking dish aerial.

It is a little over a hundred years since the first transatlantic telegraph cable was laid (1857). Telephony did not come until 1926 when the first two-way radio-telephone channel was established. Telephony by cable had to wait until 1956, for it necessitated submerged repeaters and it was not until then that they became practicable.

Now in 1962 the first experimental link using a radio repeater carried by an artificial satellite is being tested. Telstar has already shown its capabilities and successful television and multi-channel communications have taken place. In addition, business-machine type data has been transmitted at a rate approaching 1½ million words a minute.

Scientific Information

It is a commonplace that it is now a major problem to trace scientific information even when it is known to exist. So much material is published in so many places that, even with the aid of abstracting services, its retrieval is a real difficulty. So much is this the case that one American firm is reputed to find it cheaper to repeat previous work than to search for its record in the literature!

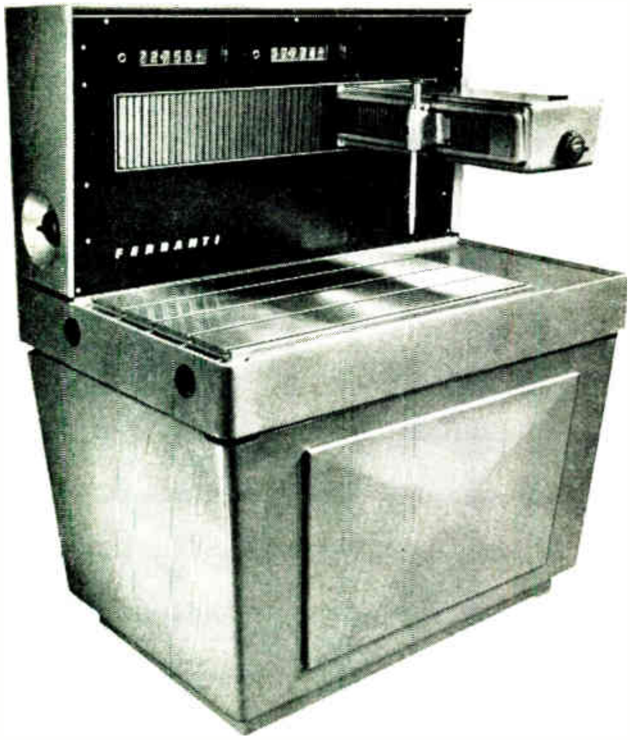
Some attempts are being made to harness electronic computers for searching for information, but the real answer has not yet been found. In the meantime new organizations to help in the problem keep being formed. One of the latest is the Scientific Documentation Centre Ltd. at Halbeath, Dunfermline.

The Centre already holds 3,500 spectra or sets of numerical spectral data. All types are collected, but primarily infra-red and ultra-violet. There is also a substantial collection of specialized data about methods of storing and retrieving information, particularly on electronic and photoelectric methods.

A Flight of Fancy

The intervals between the successive major steps in transatlantic communication are 69, 30 and 6 years. If the last were 9·3 years instead of 6, these numbers would be the cubes of 4·1, 3·1 and 2·1. However, the 6-years represents the interval to Telstar, which is experimental and not operational. If the sequence of numbers means anything, which is highly doubtful, it means that an artificial satellite system should be operational in 1965. Actually, this is by no means impossible, even if it is a little improbable.

We do not suggest that the figures are indicative of any law. However, the intervals 60, 30 and 6 years between successive major steps in the development of communications do show how the pace of development is increasing. It is an increase by no means confined to communications, but one which is occurring everywhere in technical development.



Ferranti Inspection Machine which gives a continuous display of the machine movements

Numerical control of MACHINE TOOLS

By **H. OGDEN**, B.Sc.(Eng.), A.F.R.Ae.S.*

The application of electronic and numerical control to machine tools has developed at a great pace over the last decade. This technical endeavour by the electronics industry has set the scene of a revolution in methods of production, which will ultimately affect every manufacturing industry. Some of the present applications are described in this article.

SOME proven method of linear measurement is a fundamental requirement for the control of machine movements and Ferranti Ltd. have developed the Moire Fringe measuring system (Patent Nos. 760,321 and 810,478) which has been the keystone of the Company's basic work on numerical control.

The initial element of the measuring system is a length of optical diffraction grating having a line structure at right angles to the length of the grating and a precisely known number of lines to the inch.

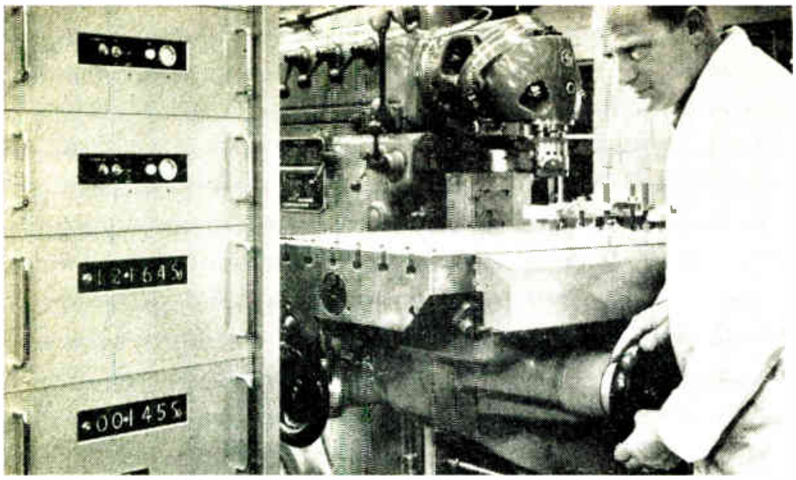
When two sections of such a grating are superimposed, at a slight angle with respect to each other, a Moire fringe pattern, with an approximately sinusoidal distribution of density, is produced as a result of the integrated interference effects caused by the angular intersection of the individual lines on each grating. Effectively, this is a greatly magnified pattern in which individual lines are easily separated.

When one grating is moved with respect to the other in a direction at right angles to this line structure, the fringe pattern travels at right angles to the direction of movement, the sense of this pattern movement being dependent on the direction of relative travel of the two gratings. The width of one fringe can be made sufficiently large to cover the full area of the index grating, which is 0·375 in. square, Fig. 1. Thus, a relative movement of one line between the main and index gratings will cause this field to go through a complete cycle of light intensity if a beam of parallel light is projected through it.

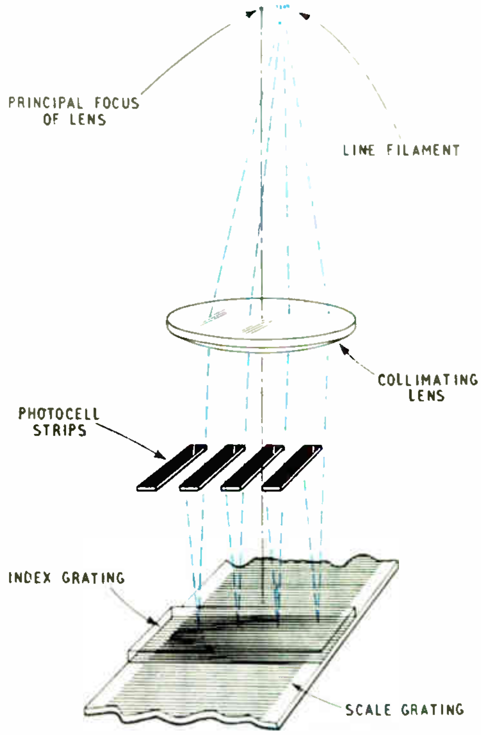
A photosensitive element integrating the light over this

Use of Addo-X printer with a control system so that a permanent record is obtained

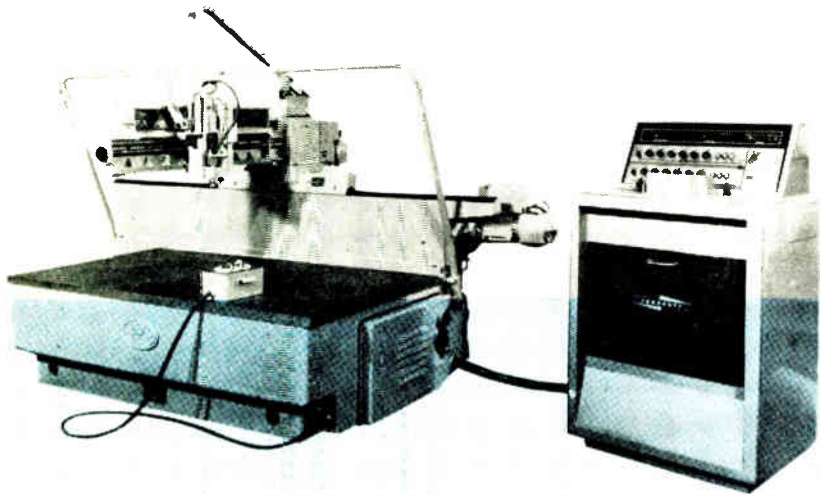
* Numerical Control Division, Ferranti Ltd., Dalkeith.



Typical application of the Ferranti electronic measuring system



Above : Fig. 1. Sketch of optical system employed with diffraction gratings for the linear measurement of machine-tool position



Left : Three-dimensional control system with H.P.E. measuring machine

field can be made to give an indication of the passage of each fringe and hence can be made to measure the relative travel of gratings.

In practice, it is required to have additional information about the direction of travel, otherwise errors will be introduced when any vibration or inadvertent reversal occurs. In order to take account of direction, it is necessary to view the pattern over two areas, the mean density variation in which differs in phase preferably by 90°. If this is the case, then electrical outputs from the photosensitive elements will be in the form of approximately sinusoidal variations in quadrature with this two-phase system containing complete and continuous information about the relative movement of the two gratings. The number of complete cycles or fractions of a cycle will indicate the total movement, the frequency will be a measure of the velocity and the direction of phase rotation will reveal the motion, and thus it is possible to use the Moire fringe effect to measure digitally lengths to a very high order of accuracy. The general arrangement of the optical system is sketched in Fig. 1.

By the use of high-speed transistorized counting circuits, with safeguards in respect to checking facilities, both of the counter and of the input signal levels, digital display techniques have been made available to industry for basic measurement for inspection and manufacturing purposes.

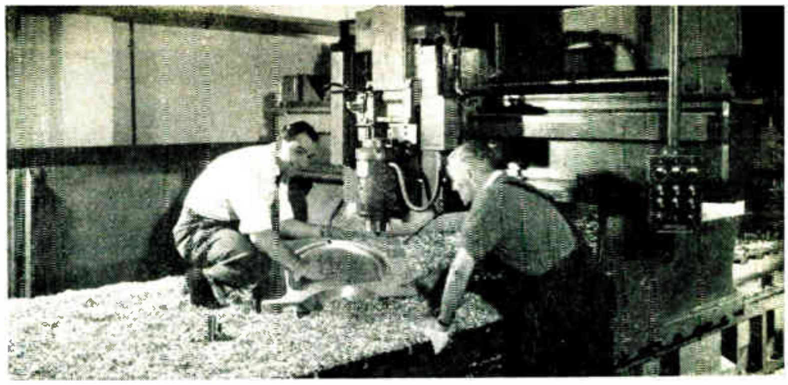
The operation of the input circuits is continuously monitored by an input check facility which will detect failure of any part of the input circuits and also indicate faulty operation due to excessive speed or inadequate photocell signal. This check operates from the logical sequence of pulses appearing within the counter and provision is made to detect any change in this sequence which would indicate the missing of a pulse from the grating system.

Additionally, the operation of the counter stages is continuously monitored by a ternary check facility which detects the counting error of one or more digits in any decade stage by means of ternary logic. In brief, each decade of the counter, starting from the most significant, is divided electronically by three, the ternary remainder being passed to the next lowest stage, resulting in a final ternary remainder after all successive decades have been operated on, which is compared with the state of a separate ternary counter derived independently from the input circuits.

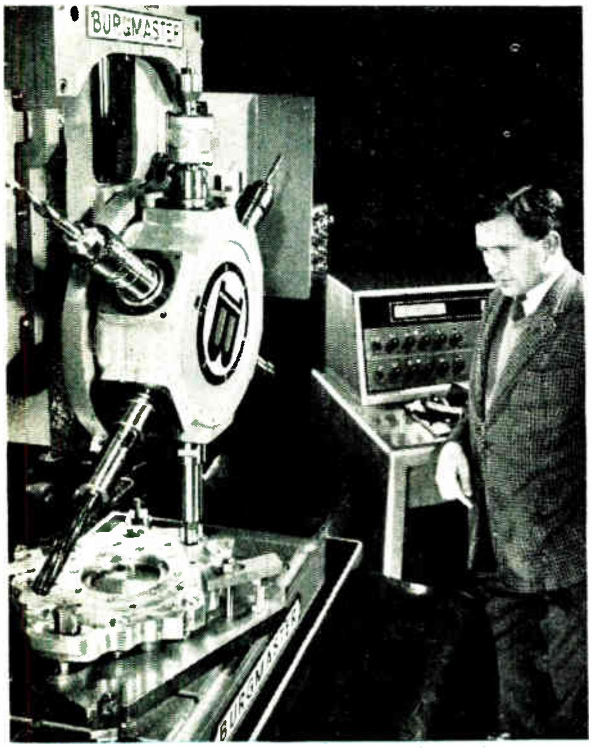
The input and ternary check circuits on the basic counter operate red warning lamps located near the decimal display and give automatic indication of the presence of a fault.

The inherent accuracy and flexibility of electronic measurement give the important operator facility of being able to zero the numerical display at any arbitrary datum and to reverse the counting direction, thus avoiding the perennial addition and subtraction calculations which result from the use of vernier and optical measuring scales.

A wide range of applications is now in hand ranging from jig borers to large lathes and horizontal boring machines. In each case the direct universal measurement achieved by electronics improves the setting time and accuracy, thus creating conditions for increased productivity with improved quality.



Cramic continuous profiling machine. The cross-feed screw has a diameter of 4 in.



Above: Two-dimensional control fitted to Burgmaster turret drilling machine

Right: The Hayes machine has three movements hydraulically controlled. The machine movements are measured at the table slide

Manual Inspection

One of the interesting areas for the application of moire fringe linear measurement scales has been for inspection purposes. The Ferranti Inspection Machine is an example of the use of this technique whereby the movements of the machine are recorded continuously by x and y digital-counter displays with the ability to reset datum and reverse counting direction as and when required. The machine movements are achieved with the use of kinematic slides which enable the machine to be positioned manually and extremely rapidly with a resulting high inspection rate.

The machine has had an extremely good reception in this country and the U.S.A. by virtue of its performance on universal two-dimensional techniques for production inspection.

In addition to direct operator display, machines have been equipped with a print-out facility operated by a conventional foot pedal, whereby the indicated position may be printed out on an Addo-X printer for permanent record purposes. Facilities are provided whereby the sequence number of each inspection operation is automatically prefixed to the x and y co-ordinate dimensions recorded, and by manual use of the Addo-X keyboard, additional information may be printed for part identification purposes.

Point-to-Point Inspection

For point-to-point co-ordinate inspection purposes the Ferranti Co-ordinate Positioning system has been associated with the H.P.E. Measuring Machine which is used for three-dimensional inspection of large areas by means of x and y, dial or tape set instructions, resulting in an automatic z measurement, which is available from an electric typewriter, or, if necessary, into a tape punch for subsequent calculation using general purpose computer techniques.

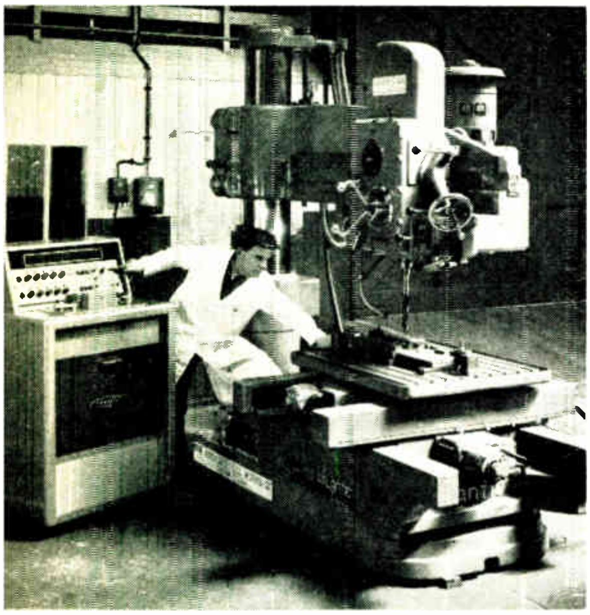
Continuous Inspection

An interesting development for continuous inspection purposes has been the application of Ferranti control to a modified jig boring machine in association with the Inspectorate of Electrical and Mechanical Engineering[1]. The basic principle of this work is the use of a high resolution control system using a magnetic tape which carries the continuous inspection instructions for the monitoring of a workpiece. Deviations from true dimensions are sensed by a specially developed contacting probe unit such that any departure in the x, y or z planes results in error measurement which is continuously recorded on a single-channel recorder.

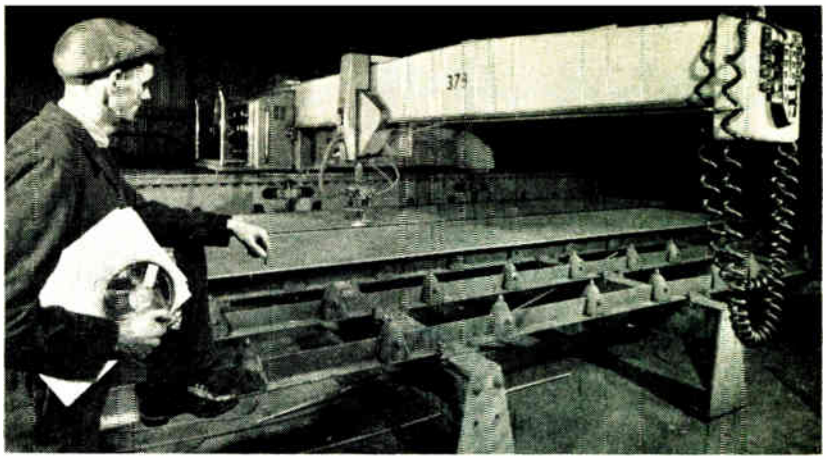
Co-ordinate Positioning

The Ferranti co-ordinate positioning system for point-to-point machine tool control uses the transistorized ternary checked counting technique referred to at the beginning of this article, but has additional facilities whereby an input demand from either dial or paper tape sets up a coincidence demand on this basic counter, and gives drive instructions to the machine.

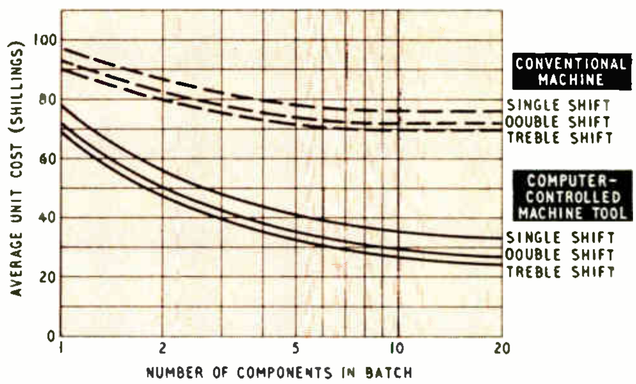
This basic co-ordinate positioning system has been applied to the Atlantic Co-ordinate Table and uses simple clutch drive gear boxes, driven by 3-phase a.c. induction motors.



Above: Atlantic Co-ordinate Table with a ternary-checked co-ordinate positioning system



B.O.C. Eagle flame-cutting machine fitted with continuous control equipment. Additionally, there are special conditions for pre-heat and flame control



Right: Fig. 2. Average unit cost of component machining against batch size for computer-controlled and conventional milling machines

On each axis the motor drive is transmitted through a high-speed traverse Warner SF.160 electromagnetic clutch by reduction gearing on to the table leadscrew until coincidence is reached; i.e., the table is instantaneously at the desired position. The high-speed traverse clutch is disengaged at this instant and the drive is transferred to the low-speed Warner SF.160 electromagnetic clutch which introduces a low-speed creep drive in the reverse direction, cancelling out the initial overshoot. On regaining the coincidence point, the low-speed clutch is de-energized and simultaneous clamping of the slide takes place.

By judicious choice of creep rate and transistor switching of the electromagnetic clutches, the fast and accurate positioning of the axis is achieved both simply and reliably.

The diffraction grating scales used on this application have an intrinsic resolution of $\pm 0{\cdot}00025$ in., with a traversing speed of 60 in./min; the table positioning performance on clutches gives a table positioning time in seconds equal to the distance travelled in inches, plus three seconds approximately.

This basic two-dimensional point-to-point positioning system has been applied to the Burgmaster range of turret drilling machines. Dial or tape instructions control the simultaneous positioning of the co-ordinate table and the index position of the turret head. When these instructions have been carried out, the drill cycle is initiated and the next instructions are read by the tape reader. On completion of the head movement, the next operation is carried out and thus the machine cycle is completed automatically by numerical instructions.

In order to compete with conventional multi-head drill stands, and associated drill templates, on this class of work, it is necessary to look for the minimum positioning and index cycle time. In the case of this range of machines, the table is positioned by hydraulic rams and a special electro-hydraulic control valve which is of the five state type; i.e., rapid traverse in either direction, slow creep in either direction with a clearly defined dead zone. Rapid traverse is 200 in./min with a setting time of less than 1 sec for a positioning accuracy of $\pm 0{\cdot}001$ in.

The basic co-ordinate positioning system has been further developed and includes special features for milling functions, etc. In the case of large co-ordinate positioning machines, such as horizontal borers, it is necessary to provide multiple anticipatory features on the co-ordinate positioning cycle to permit the machines to decelerate in an optimum manner.

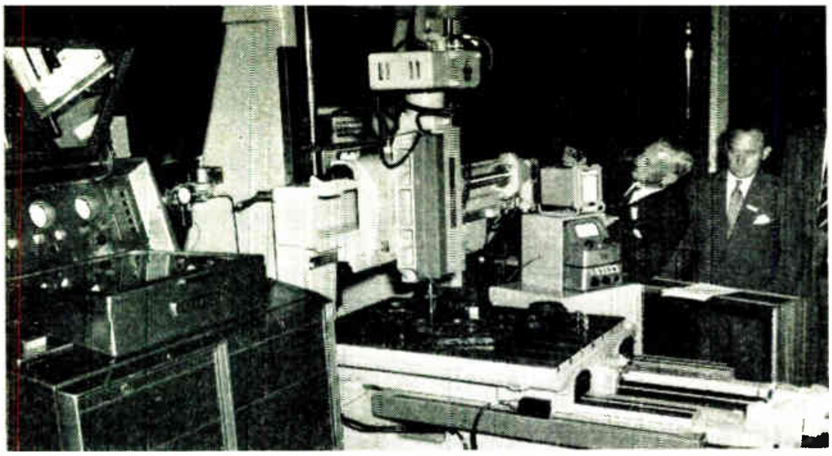
Continuous Control

The continuous control of machine tools has been a major development by the electronics industry with the aircraft and associated industries very much in mind. The position now is much broader since the efforts in data processing of the numerical information has advanced and inevitably a wider range of industries is finding economic gain by the use of this type of machine.

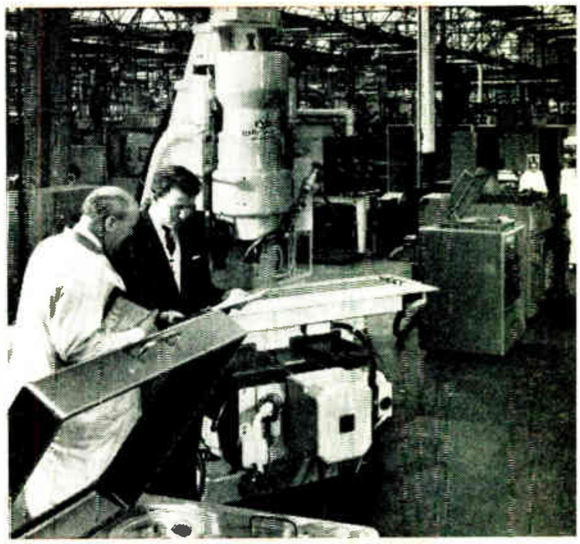
Ferranti Ltd. has done a tremendous amount of pioneering work on this concept which is now defined as the computer control of machine tools and has culminated in the development of the Ferranti Mk. IV continuous control system.

The equipment incorporates transistor techniques and hydraulic servomechanisms with linear grating feedback, using a magnetic tape system and a centralized computer service for data preparation. This philosophy of control enables a computer centre to prepare the machining data for a large number of machine tools and by having this data preparation out with the machine, considerable economies are possible in the control equipment, together with benefits of simplification and associated reliability.

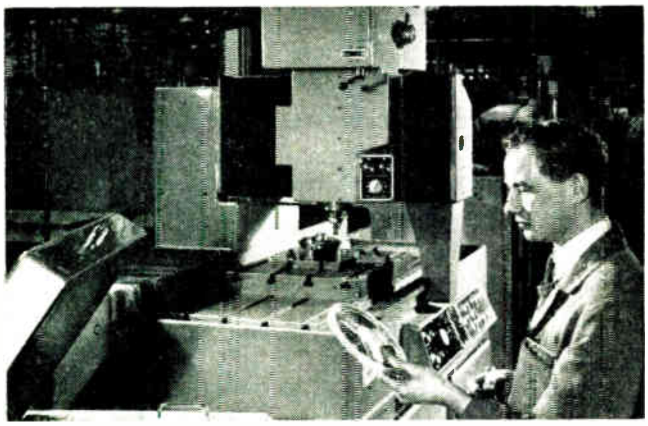
Further, the general advance of data processing tech-



Left: Continuous inspection instructions recorded on magnetic tape are used in this jig-boring machine



Above: In the Kearney and Trecker, C.V.A. TF.415, recirculating ball leadscrews are used and magnetic tape control



Left: Ferranti Mk. IV continuous control fitted to an H.P.E. Contourmatic machine

niques is available to users of the system to increase the facilities of the associated machine tool.

Briefly, the control cabinet contains the magnetic tape deck, electronic equipment and power supply for the three-axis control of the machine tool. The electronic circuits are on printed-circuit boards, which are plugged into removable trays so that each axis of the machine is controlled from a single tray, with a fourth tray for reference channel purposes. The unit is furnished with a spare control-channel tray and spare reference-channel tray. By visual fault indication techniques, a defective channel can be replaced immediately by a spare channel and thus repairs to the defective tray can be carried out at leisure.

Measurement of the machine movement uses a reflecting grating technique and thus the movements are measured at the table slide and not through the inaccuracy or compliance of the machine tool transmission. As previously mentioned, hydraulic servomechanisms are fitted as standard with a continuous control equipment and the type of drive is dependent largely on the size of the machine tool

In the case of the Hayes machine illustrated, this is by hydraulic rams on the three movements of the machine, giving a travel of 19 in. × 9 in. with 3 in. of control movement on the z axis with an ability to reset over a length of 12 in. of knee travel.

With larger knee-type milling machines, such as the Kearney and Trecker, C.V.A. TF.415, the size of the machine dictates the use of recirculating ball leadscrews, and the drives to these screws are by hydraulic motors through backlash-loaded gearboxes. However, with the large continuous profiling machines, the transmission stiffness becomes very critical and a resort is made in the case of the Cramic machine to rack gearboxes in the case of the gantry movement of the machine.

Readers who are familiar with the general problem of machine-tool design requirements for numerical control should note the massive cross feed screw on this machine, which is of 4 in. diameter.

The H.P.E. Contourmatic machine with Ferranti Mk. IV continuous control uses an interesting combination of drive techniques to achieve maximum performance at minimum cost. It has hydraulic screw drive on the longitudinal feed, together with hydraulic ram transmission on the transverse and vertical axes.

This machine has been designed for electronic control and uses Dexter-type slides with a variable speed hydraulic motor on the machine tool spindle in the interests of good speed regulation and high power to weight ratio.

The B.O.C. Eagle Flame-Cutting Machine is an interesting application of Ferranti continuous control equipment, since while this is two-dimensional, the interlock and miscellaneous functions with regard to pre-heat, flame monitoring and general cutting cycle, together with special data presentation, represent unique developments[2]. Position measurement on this machine is by synchros built into the traverse gearboxes.

Economics

It is fundamental that capital investment in electronically-controlled machinery should be accompanied by increased productivity with lower unit cost per item as compared with conventional production techniques.

The main factors in this economic statement are related therefore to product complexity and batch size with skilled manpower utilization, product lead time, quality, accuracy and overhead structure of planning, progress, and inspection, additional factors of increasing importance in modern industry, but as yet incapable of being expressed in general quantitative terms.

Milyard and Brewer[3] suggest a criteria for the economic advantages and disadvantages of continuous contour control systems related to a fixed batch size of 10 components, the aim concerned being component complexity expressed by geometrical considerations. Briefly, the number of straight lines parallel to a machine axis and the number of curves which can be specified simply by the data-processing medium are compared; if numerically in favour of the curvaceous component, economics of manufacture lie with numerical control.

It is further suggested that if the number of decelerations is higher than 50 (this might be better expressed as the number of co-ordinate change points), then the advantage will always lie with numerical control.

Case studies carried out by Ferranti Ltd. substantiate this economic criteria, although at the present moment batch size below 10 components requires closer investigation and straight-line components require understanding since these are undoubtedly more suitable to electronic-controlled straight-line millers, but not necessarily continuous control.

The average results for 14 detailed case studies carried out on behalf of a manufacturing company, with material ranging from gun metal to steel and cast iron, give the basis to Fig. 2, which is a plot of average unit cost for a numerical continuous-controlled milling machine, typical of the Kearney & Trecker, C.V.A. TF.415, against batch size for single-, double- and triple-shift working. It is interesting to note that apart from the economic savings, the productivity of the machine is up by a factor of eight over the conventional milling machine.

It has been pointed out that co-ordinate positioning machines are in direct competition with multi-head drill stands and the economic case for this class of machine resolves itself into a comparison of drill jig, and fixture costs for batch production against the increased capital cost of paper-tape positioning controls.

Such cases require to be treated on their merits. The present emphasis, whereby numerically controlled co-ordinate positioning machines are doing combination work (i.e., drilling, boring, reaming, milling, etc., at one set up), has a substantial effect on the overhead structure normally related to these machine shop operations, in the areas of planning, rate fixing, progress and inspection. In addition, there is the attractive floor-to-floor time of such combined operation.

In the areas of short batch production, while the process need not necessarily be 'automated', gains in productivity can be realized by electronic facilities to aid skilled operator utilization in such matters as setting-up, limiting arithmetic, gauging, etc.

It is interesting to note that several contract machine shops in this country and in France are now using Ferranti numerically-controlled machine tools. It will be appreciated that it is fundamental in contract machine work to produce the required components more efficiently than the contracting company in order to survive.

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[2] R. R. Sillifant, 'Automatic Gas Cutting Machines for Shipyard Use', Institute of Welding, Joint Symposium on Welding in Shipbuilding, 30th October–3rd November, 1961.

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VALUE ENGINEERING

Value Engineering Ltd., a subsidiary of Value Analysis Incorporated, U.S.A., has been formed in England to provide British industry with value engineering and analysis services which are aimed to produce a 25% or more saving in production costs.

The services offered by Value Engineering are somewhat similar to time and motion study with the addition of fundamental design studies and a basic training course for the customer's staff. These services are referred to as the application of 'value analysis' which, by formal definition is a system of techniques and planned methods by which individuals learn to look objectively and with imagination at a part, a material, an operation, or a project, comparing the cost of these things with the function performed.

When called upon to implement value analysis Value Engineering would in a typical case organize and conduct training sessions for a number of the customers' managers and project leaders. These sessions would normally last for about three or four days and would include personnel representing design and development, production, and purchasing departments. At the training sessions a team made up from personnel from the various departments would study a project, from either the sales department or some internal source, under the leadership of an expert in value analysis. The initial goal of the team would be the reduction by at least 25% of the manufacturing costs of the parts and/or product being studied.

It is claimed that by making all of the team aware of the various factors affecting manufacturing costs, new materials and techniques available, and services offered by outside suppliers, etc., it is possible to bring about a reduction of manufacturing costs for most products. At the end of the training session the team would be capable of applying the techniques learned to other projects.

Value Engineering state that from past experience it is possible to plot a graph showing the return of capital invested in value analysis against time and this shows that the return is ½ : 1 at the end of the first three-month period, 4 : 1 after six months, 8 : 1 after nine months and 10 : 1 after 12 months; thus after 12 months for every £1 invested in value engineering (including capital invested in additional equipment) there is a saving of £10.

Over 40 companies in the United States have used the services of Value Analysis Inc., and case histories of many of the projects are available.

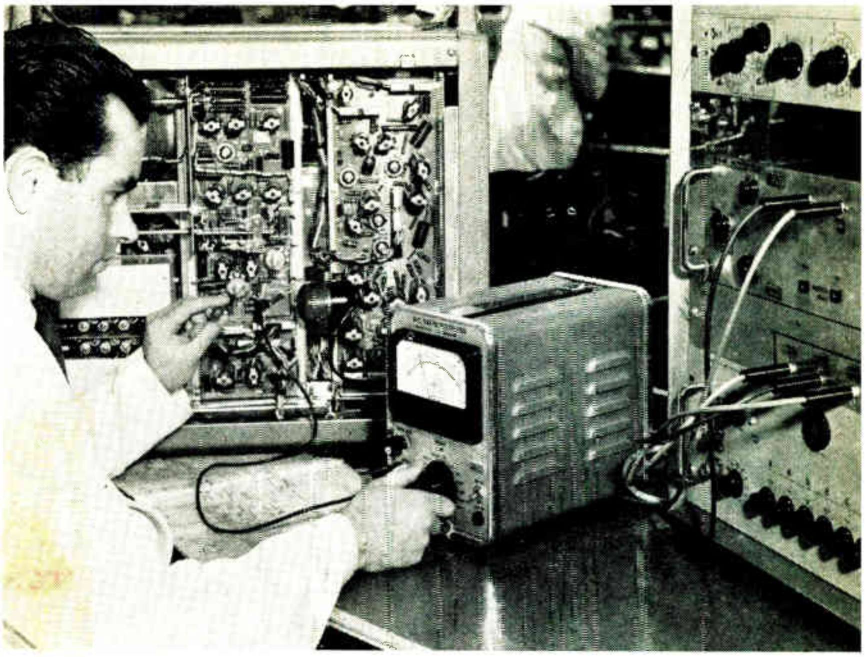
For further information circle 39 on Service Card

APPLICATIONS ILLUSTRATED

Portable d.c. valve voltmeter

Minifon wire recorder

Voltage surge indicator



Here the Dawe Instruments portable d.c. valve voltmeter type 611A is being used to measure potentials from 30 µV to 1 kV on a storage oscilloscope. With an input impedance of 100 MΩ, except on the most sensitive ranges, the valve voltmeter presents a negligible load to the circuit being tested

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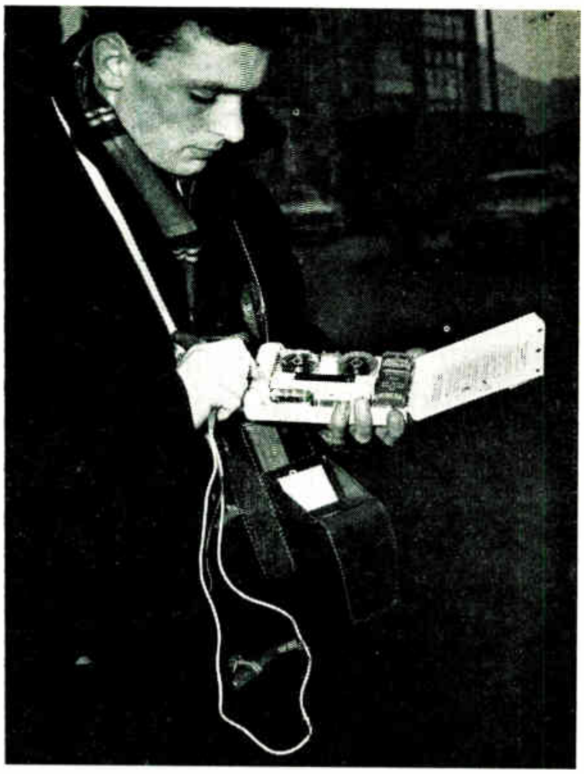

As part of a series of traffic flow surveys within the City of Leeds on-the-spot recordings of vehicle registration numbers were made with the Minifon wire recorder type P.55.S. Initial tests carried out proved that one enumerator dictating every registration number could cope with occasional rates of up to 2,000 vehicles per hour. With good practice an operator can transcribe a 1-hr long recording in about 2 hours. Illustrated here is the Minifon which has been opened for replacement of the reel of magnetic recording wire

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Supplied from its own battery this A.E.I. surge indicator will enable on-the-spot checks to be made for voltage surges likely to be harmful to electronic and electrical equipment during manufacture, installation and maintenance. The voltage measuring range is 100 V to 1·5 kV and the input resistance is 4 MΩ

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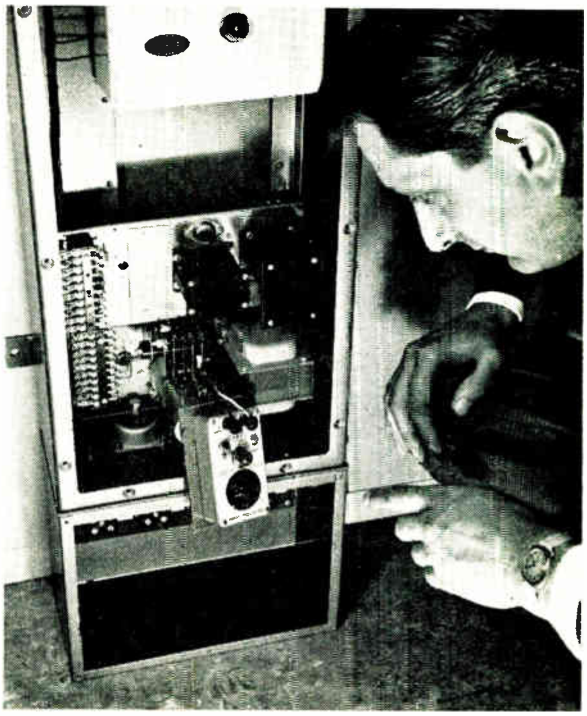


INDUSTRIAL

TEMPERATURE MEASUREMENT

By K. A. FLETCHER*

A new form of thermometer for industrial application is described. It is based upon the mercury-in-glass thermometer, but the capacitance between the mercury and an external conductive coating is measured. Remote indication of temperature is easily achieved and an expanded scale about any desired mean can be arranged.

DEVELOPMENT of the transformer ratio arm bridge has made accurate and stable measurements of small capacitances possible. One application of this technique permits the column of mercury in a thermometer to be treated as the inner electrode of a coaxial capacitor and this allows a robust and reliable measurement of temperature to be made. Mercury-in-glass thermometers are still regarded by the majority of chemists and engineers to be the most satisfactory indication in the intermediate range and this article describes a bridge and transducer system built around a precision mercury-in-glass thermometer.

The implications of this system, however, go beyond the ordinary laboratory or chemical plant requirement. Mercury-in-glass thermometers suffer from two principal instabilities which preclude their use if very small temperature differences, of the order of a few millidegrees, are to be observed. If the mercury capillary is watched under a microscope when the thermometer bulb is cooling, it will be seen that the column contracts in a series of small jumps, each between one and ten millidegrees in length on the temperature scale[1].

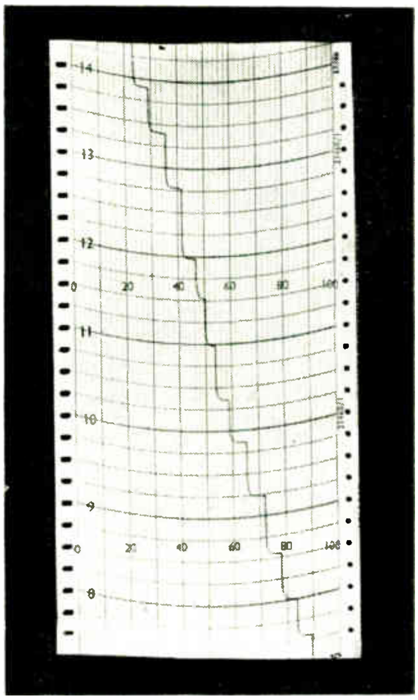
This effect is due to the compound forces of stiction in the capillary and contraction of the main mass of mercury in the bulb, which appears to draw the thin shell of the bulb into an hour-glass shape during each jump. A robust bulb partly helps to overcome this difficulty but the thermal time constant of the thermometer deteriorates considerably if the bulb thickness is made too great. The second instability is due to the supercooled fluid nature of the glass itself. A drift of a few millidegrees per year is caused by a gradual flow of the glass in the bulb under the pressure of the mercury. This can be eliminated by using quartz instead of glass in the construction of the thermometer.

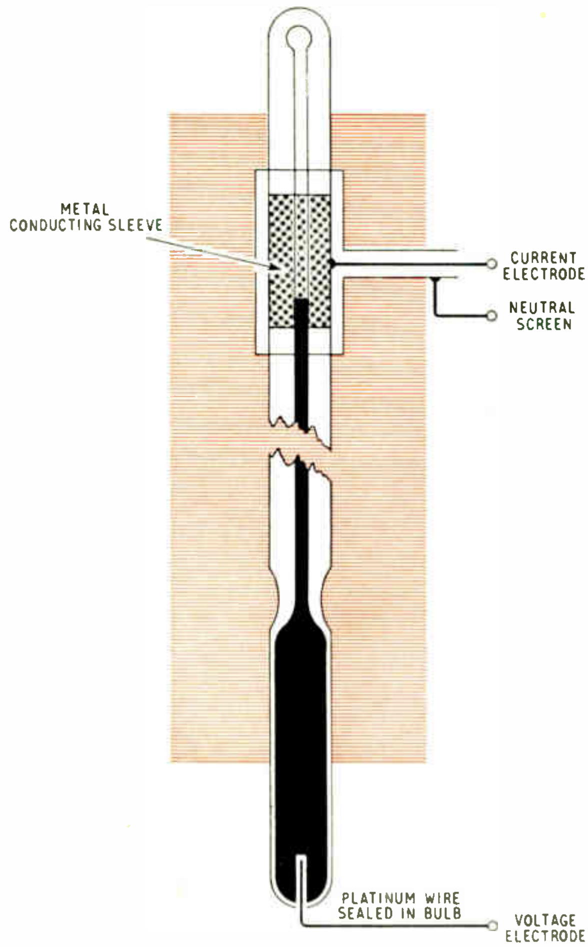
Experiments conducted with a mercury-in-quartz thermometer fitted with coaxial electrodes, as described in a later section, have enabled chart recordings to be made of the jumps occurring due to the cooling of the bulb. Fig. 1 shows the irregular contraction occurring as the mercury cools. The width of the chart is equivalent to 0·030 °C and the thermometer was cooling from 25·0 °C at a rate of 0·16 °C per hr (1 in. per min chart speed). It was observed during these experiments that if the thermometer was connected to a small moving-coil vibrator and gently vibrated at a low frequency the steps disappeared and a smooth rundown resulted. This move could not be made with an optically read thermometer but appears to enable the mercury-in-quartz thermometer to be used as a stable transducer in conjunction with an a.c. bridge[2] with an inherent accuracy of at least 0·001 °C.

Temperature Measurement and Control

At temperatures of the order of 30 °C, platinum-platinum/rhodium thermocouples have a sensitivity of 6 μV per °C and, while the thermocouple itself is very stable, the instrumentation required is extremely delicate if a high order of discrimination is required. A similar difficulty exists with platinum resistance elements which have a temperature coefficient of 0·0039 per °C. This means that an element which measures 100 Ω at a given temperature will change by about 0·4 Ω per °C, and if a few hundredths of a degree

*The Wayne Kerr Laboratories Ltd.





Above: Fig. 1. Chart recording of irregular contraction of mercury capillary in a thermometer

Right: Fig. 2. Mercury-in-glass thermometer and capacitance transducer arrangement

discrimination is required, a very stable bridge circuit and recorder amplifier arrangement are necessary. Although it can be argued that few industrial processes require temperature to be recorded more accurately than one degree or so, the advent of plant prediction and optimizing techniques requires minute changes to be observed and entered into the computer rate of change calculations, so that the maximum time may be available for corrective action to take place.

Thermistors are gaining popularity as temperature transducers and, while recent work indicates that they are capable of greater stability and repeatability than was previously supposed, they are still liable to random fluctuations and drifts, particularly if subjected to mechanical or thermal shock, or if they are operated at too great a power level in the measuring circuit. The advantage of the capacitance transducer thermometer is that a linear change of capacitance is measured over a large or small range of temperature according to whether a coarse or fine capillary is used in the construction of the basic thermometer unit and therefore the order of discrimination can be chosen. The calculations in the next section show that the capacitance for various diameters of capillary varies as a logarithmic function, and therefore the instrumentation problem is made easier for a large range of sensitivities.

Capacitance Transducer

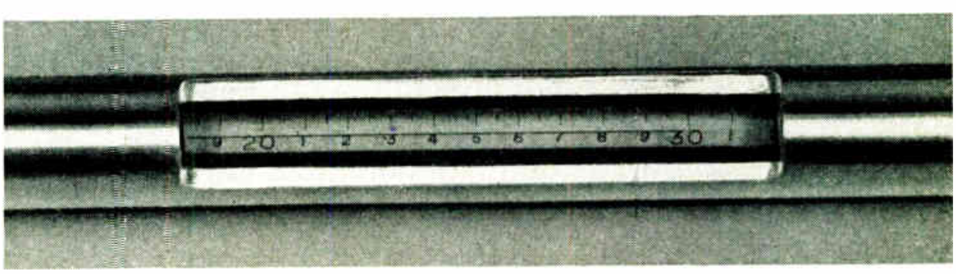
If the surface of the stem of a thermometer is made electrically conducting, the mercury becomes the second terminal of a coaxial line as it rises in the capillary, and the capacitance in picofarads per millimetre is given by the following formula:—

$$C = 0{\cdot}242\epsilon \log_{10} (D/d)$$

where ϵ is the dielectric constant of the glass
D is the inner diameter of the conducting tube
d is the diameter of the mercury column in the capillary tube.

As the diameters D and d occur as a fraction, they may be

Fig. 3. Close up of thermometer scale through conducting glass sleeve and Pyrex window



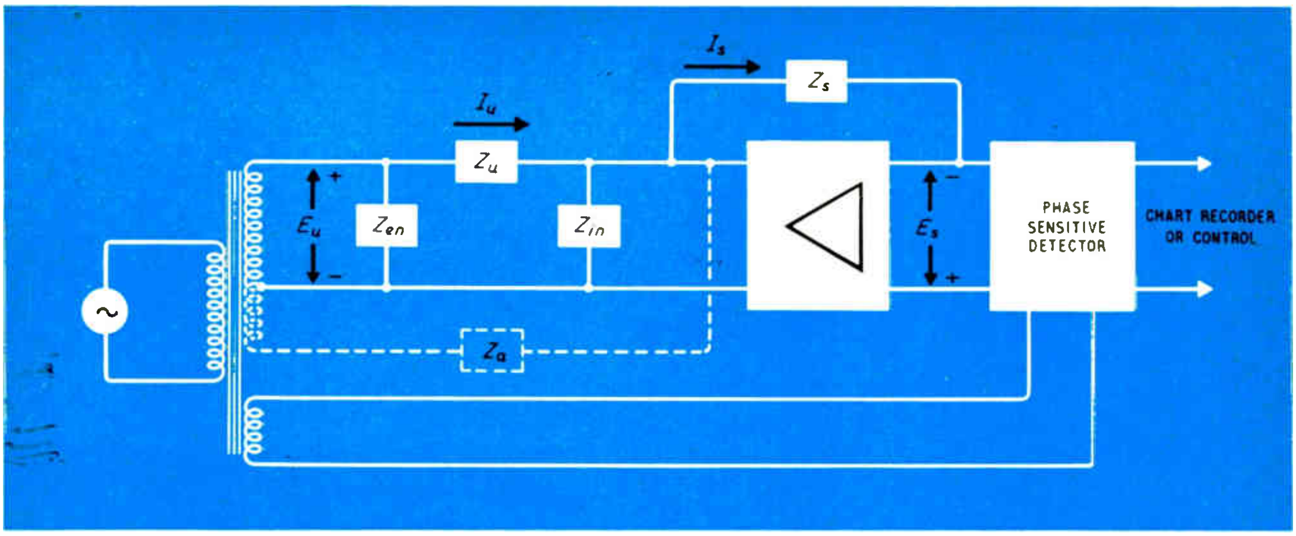


Fig. 4. Circuit diagram of bridge

measured in inches or millimetres, the conversion constants dividing out.

The capacitance is proportional to the logarithm of the ratio of the diameters; this means that thermometer capillary tubes of large diameter do not give a great increase in capacitance per unit length, as Table 1 indicates, D in this case being taken at 0·25 in., a fairly common diameter.

Table 1

Diameter of Capillary (in.)	$\log_{10} D/d$
0·002	2·10
0·004	1·80
0·006	1·62
0·008	1·49
0·010	1·40
0·012	1·32

If it is assumed that no discontinuity exists between the conducting tube and the thermometer wall (i.e., that the diameters are identical and that there is no distortion of either cylinder) a typical value of capacitance per unit length would be 0·12 pF/mm, taking the dielectric constant of thermometer glass as 6·8 and $\log_{10} D/d$ as 1·40. In practice the conducting sleeve fitting the thermometer stem is a sliding fit and is cemented in position with a thin film of epoxide resin (dielectric constant about 3·5), but this film represents only a minor part of the effective dielectric.

Fig. 2 shows the schematic arrangement of a thermometer assembly. In practice the metal conducting sleeve surrounds only part of the diameter of the thermometer, allowing the thermometer scale to be observed visually while the electrical measurement is being made.

This reduces the electrical capacitance per unit length by a proportionate amount. A transparent conducting sleeve is fitted over the foil electrode forming a neutral screen and preventing flux lines leaving the system to cause errors from hand movements and surrounding apparatus. This sleeve is a glass cylinder with a tin-antimony oxide conducting film fired on to the outer surface only. The oxide film has a slight bluish tinge, but is transparent enough to permit the visual observation of the thermometer stem and mercury column. Fig. 3 shows a close-up of a thermometer scale viewed through an oxide film electrode. Connection to the mercury is made by a platinum wire sealed into the bulb and the oxide film neutral screen prevents external flux lines occurring between the foil electrode and this connection.

The design of the mercury-in-quartz transducer, required for critical measurement and control purposes beyond the limit of visual observation, employs a copper electrode fired on to the full diameter of the quartz stem. The whole transducer is placed in a continuous stainless steel tube which forms the neutral screen, and connection to the mercury is made by means of a second fired-on band at the bulb. This band gives a fixed transfer capacitance into the system in series with the variable capacitance from the capillary. It is necessary because at the present moment no satisfactory means appears to exist for sealing platinum wire into quartz and the slight non-linearity occurring is perfectly stable if fired-on electrodes are used. Five per cent non-linearity occurs if the bulb electrode capacitance is 20 pF and the mercury has risen to give 1·0 pF capacitance in the stem. Both types of transducer can be made to cover portions of

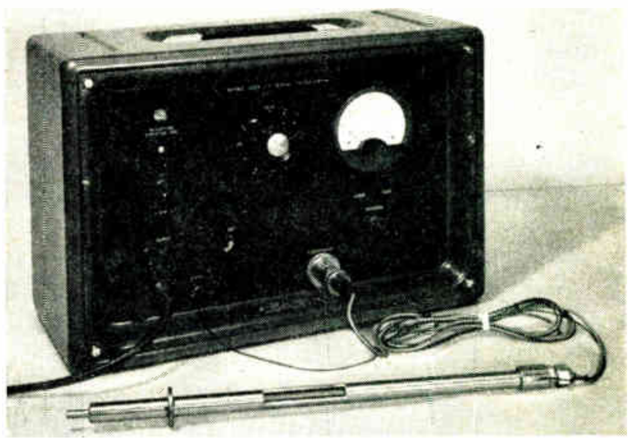


Fig. 5. Thermometer bridge together with mercury-in-glass transducer

the temperature scale up to at least 200 °C, and low temperature versions employing mercury-thallium alloy can be made for temperatures as low as −55 °C.

Transformer Ratio Arm Bridge

The measurement of small capacitances requires, apart from a neutral electrode facility, extreme stability in the bridge network. Both requirements are met by the transformer ratio-arm bridge, which is now in general use where capacitance transducers measuring small distances, vibrations, permittivity, etc., are employed[3,4].

Fig. 4 shows the basic arrangement of a self-balancing bridge capable of operating a chart recorder, control system or alarm circuit.

The amplitude-stabilized oscillator feeds a transformer providing a phase reference voltage and the unknown voltage E_u. The resultant unknown current I_u flowing through the impedance of the thermometer Z_u is practically balanced by I_s, the feedback current derived from E_s and Z_s, E_s being the output voltage from the high-gain amplifier which is applied to the phase-sensitive detector. Because I_u and I_s are almost equal very little voltage appears across Z_{in} and Z_{en} shunts the transformer secondary. These elements, therefore, do not affect the accuracy of measurement.

In the phase-sensitive detector the reference voltage is added to and subtracted from the amplifier output to provide sum and difference signals which are rectified to provide a d.c. output. The phase-sensitive detector ensures that the indicated impedance is a true capacitance and is not influenced by the tan δ term for the glass wall of the thermometer.

If it is required to record from only a part of the thermometer scale a third secondary can be wound on the voltage transformer, indicated by the dotted winding, providing a 'backing-off' current enabling part of the capacitance of the transducer to be cancelled. If Z_u is a capacitance such that 0 pF occurs at 10 °C (the mercury column just entering the coaxial electrode at this point), and 6 pF capacitance is measured when the mercury is at 40 °C, the output voltage from the phase sensitive detector can be made to cover say 30–40 °C by backing off the first 4 pF, adjusting Z_u (a pre-set capacitor), and setting Z_s (a second pre-set capacitor), so that the remaining 2 pF gives the required maximum output voltage. By this means 'zero and span' adjustments are possible, and by tapping this secondary winding in 10 equal taps a decade control can be added so that a progressive backing off is provided to give a series of outputs, each step being one-tenth of the scale covered by the electrode system.

Fig. 5 shows a complete self-balancing bridge together with the mercury-in-glass transducer illustrated in Fig. 3. The decade switch is arranged so that the meter indicates any step of one degree between 20 and 30 °C. A chart recorder or control circuit can be attached in parallel with this meter and an additional tap on the first secondary winding E_u provides a voltage of one-tenth the normal voltage so that the output circuit, and hence a chart recorder, can indicate the full range 20–30 °C if desired.

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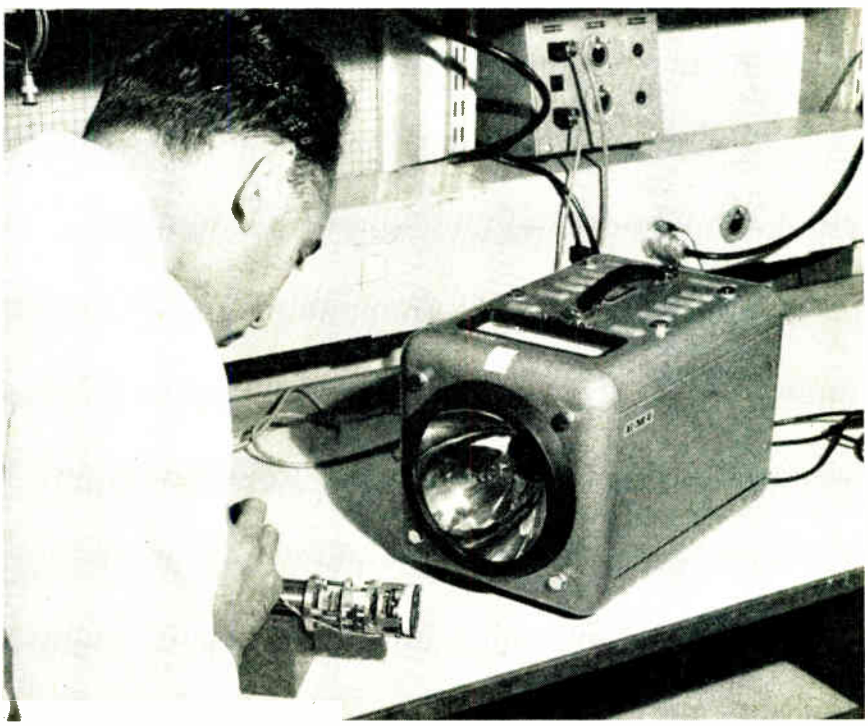
Stroboscopic Testing of Motor Generator



To maintain the high accuracies required, the motor generators governing the fuel flow in B.O.A.C.'s aircraft are checked during regular servicing by means of an E.M.I. stroboscope. The high speed rotating mechanisms in these generators are illuminated with flashes of light, so timed that the rotors appear stationary. The speed can then be determined accurately by reading off the frequency of the light flashes on the stroboscope dial

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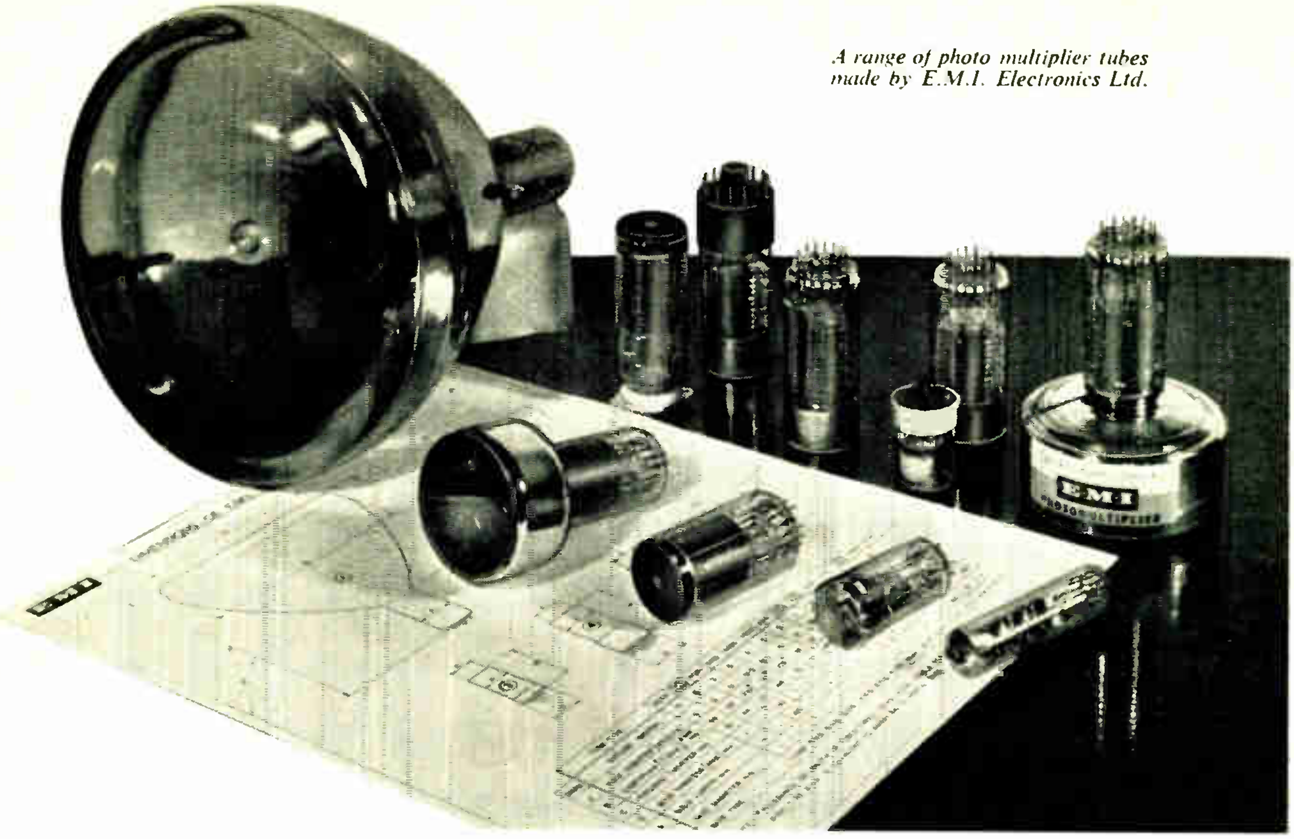


A range of photo multiplier tubes made by E.M.I. Electronics Ltd.

VACUUM AND GAS PHOTOCELLS

By J. SHARPE, B.Sc., A.M.I.E.E.*

There are so many industrial applications of photoelectric cells, that a wide variety of types of cell is needed to meet the requirements. This article describes the characteristics of that broad class of cell in which the action takes place in an evacuated or gas-filled envelope, usually of glass.

WITHIN the visible spectrum of 0·4 to 0·76 micron, the sensitivity of the eye varies in the way shown in Fig. 1. If light values are to be recorded instrumentally so that they correspond with the brightness seen by the eye, the spectral response of the photocell must approximate to this curve and this usually necessitates the use of correcting filters between the light and the photocell.

Visual light power is measured in lumens, 4π lumens being emitted by a standard candle. However, this is now often expressed in terms of the radiation from a standard tungsten lamp operating at 2,870 °K. The power in one lumen between 0·4 and 0·76 micron wavelength, from such a lamp is 6 mW. The spectral content of light from a hot body depends very much on temperature, as shown in Fig. 2, but it must be remembered that gas-discharge lamps give quite different distributions of energy with wavelength.

The range of wavelengths with which we are concerned in this article is shown in Fig. 3, together with indications of the upper and lower cut-off wavelengths of transparent materials used for windows and the relative quantum energy in electron-volts.

Photoelectricity

Light interacts with matter in the form of 'packets' of energy, or 'quanta', of value $1{\cdot}238/\lambda$ electron-volts per micron. The electron volt is equal to $1{\cdot}6 \times 10^{-12}$ erg, and one lumen of green light, of power 1·6 mW, is carried by $4{\cdot}5 \times 10^{15}$ quanta, or photons, of 2·55 eV.

When a quantum is absorbed it may overcome the forces binding an electron in place, and in a photosensitive material the electron may be ejected from the surface (photoemission), or may be free to move about the solid

*E.M.I. Electronics Ltd.

under the influence of an electric field (photovoltaic and photoconductive effect). The electron binding energy sets a threshold to this effect, so wavelengths longer than a critical value, depending on the material, give no photoelectric effect, but as the quantum energy increases past the threshold the effectiveness increases to a maximum to fall off again as the higher energy quanta are absorbed in the window of a photocell, or in insensitive surface layers.

The spectral response curves of photoelectric materials suitable for photoemissive cathodes are thus as shown in Fig. 4, rising to a maximum and falling off again at shorter wavelengths, and the sensitivity is expressed in quantum efficiency (electrons per photon), although the curves could have been drawn in terms of amperes per watt of radiation.

Photoemissive Cells and Multipliers

Two types of photocells are shown in Fig. 5, (a) having an opaque cathode, while (b) has a semitransparent surface. In both types a thin layer of metal, such as antimony, is evaporated in vacuo at room temperature, and then exposed to caesium vapour at 150 °C to form $SbCs_3$. At room temperature the Cs vapour pressure drops to 10^{-6} mm Hg (other surfaces are formed by reacting Cs with AgO, with BiAgO, and with $Sb(NaK)_3$). Under illumination, electrons are emitted from the cathode and drawn across to the anode, which is at 30 to 150 V. The sensitivity may conveniently be expressed in microamperes per lumen of incident light from a lamp of colour temperature 2,870 °K (Table 1). The smallest measurable intensity is set by the cathode sensitivity, by the dark current flowing from the cathode due to thermionic emission, by leakage, and by noise which may be shot noise from the cathode and dark current, or Johnson noise from the anode load. In all but the most carefully made cells, leakage and Johnson noise predominate at low light levels (Table 2). Vacuum cells are almost always operated with high values of anode load in excess of 1 MΩ, and sometimes as high as 10^{12} Ω, under essentially d.c. conditions for the accurate measurement of medium to high light levels in photometers, etc.

The effects masking the fundamental limitations of dark current and shot noise can be minimized if the cathode current is amplified before reaching the anode, and this is done in gas-filled cells, which contain a low pressure of argon. As electrons move from cathode to anode they cause multiple ionization in the gas, giving free electrons and positive ions, and the gas multiplication factor rises rapidly as the voltage across the tube increases, typically going from unity through 5, to 10, as the voltages rise from 15 V, through 65, to 85 V. Gains higher than 20 are rarely used, and a protective resistance of some 100 kΩ must be used to prevent damage under excessive illumination. The frequency response of this type of cell is limited by de-ionization effects, and falls off sharply above 10 kc/s.

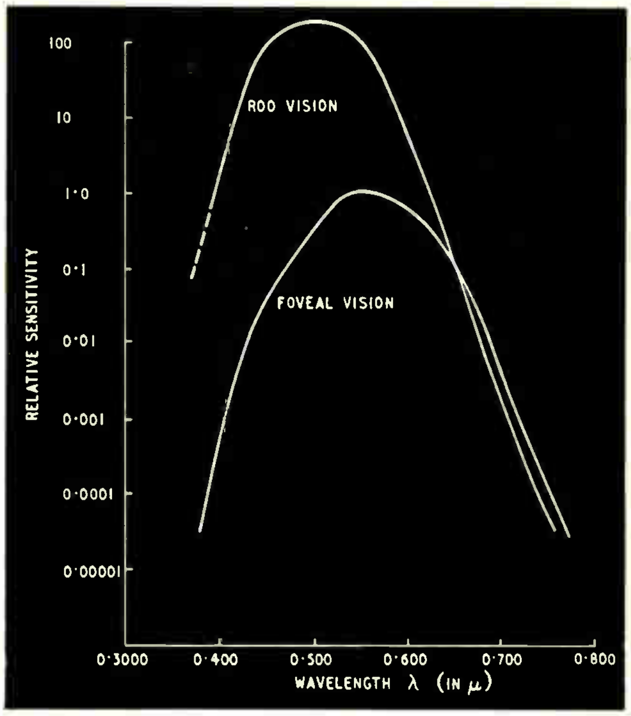
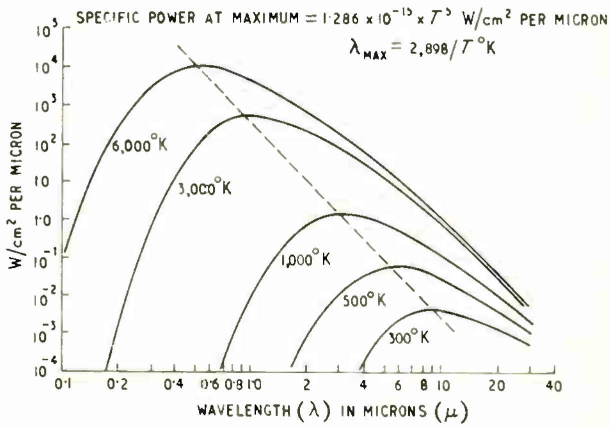


Fig. 1. Variation of eye sensitivity with wavelength of light for foveal and rod vision. The curves are the average of many observers

Fig. 2. Spectral distribution of radiation from hot black bodies ($1\ \mu = 10^4$ Angstrom units $= 10^{-6}$ metre)



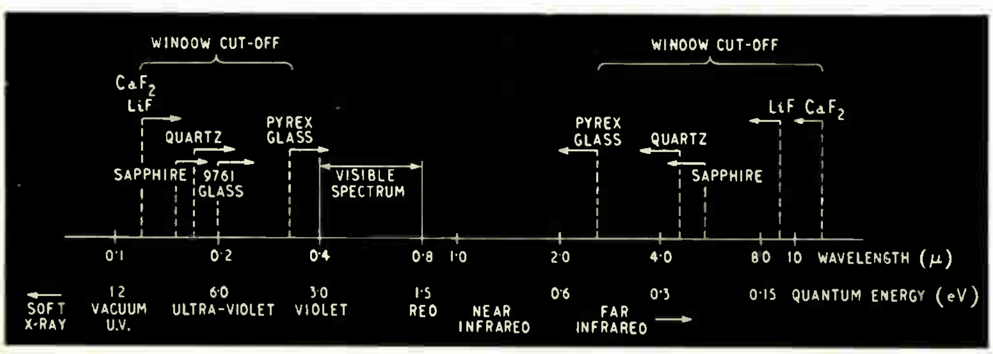


Fig. 3. This diagram shows the relation between the wavelength of light and quantum energy in electron-volts and also indicates the transparency ranges of materials used for photocell windows

TABLE 1
TYPICAL PHOTOCATHODES
(Glass windows except where noted†)

Photocathode	Form	Peak Sensitivity λ	Peak Sensitivity Quantum Efficiency	Long Wavelength Threshold	Typical Sensitivity (2,870 °K lamp)
		μ	Electrons/photon	μ	μA/L
SbCsO (S–11) ..	Semi transparent	0·42	0·15	0·67	60
SbCs (S–4) ..	Opaque	0·45	0·10	0·7	40
SbCs (EMI 'S') ..	Semi-transparent	0·42	0·12	0·65	40
Sb(NaK)Cs (S–20)	,,	0·44	0·20	0·85	150
BiAgOCs (S–10)	,,	0·45	0·05	0·8	35
AgOCs (S–1) ..	,,	0·8 (also in blue)	0·004	1·2	15
†Mg (quartz window)	,,	< 0·2	0·004	0·39	—
†Au (quartz window)	,,	< 0·2	0·0001 to 0·00001	0·27	—

but this is of little importance for its main use in film projector sound heads.

Photomultipliers

A more effective way of achieving noiseless current multiplication is by the use of secondary emission, and the most commonly used arrangements are shown in Fig. 6. Each of the intermediate electrodes between cathode and anode, the dynodes, is coated with a good secondary emitter and run at a positive potential to its precursor so that electrons are accelerated from the cathode on to the first dynode, and then on through the tube, producing secondaries at each dynode. Since the number of secondaries per primary electron varies with incident electron energy as the voltage to the power of 0·7 for the commonly used SbCs dynode coating, the overall gain for a tube with n dynodes fed in the usual manner from a potential divider chain with a total supply voltage of V, varies as $V^{0\cdot7n}$. Since n is usually between 9 and 15, the supply voltage to a p.m. tube must be very accurately controlled if stable gain is to be achieved (Fig. 7). Of the dynodes illustrated, the box and grid type is the most efficient, with the highest gain for a given voltage, while the focused structure has the fastest time response, with an upper frequency of 300 Mc/s compared with the 50 Mc/s of the box and grid. The venetian-blind type is intermediate for gain and speed but gives the best dark current.

Electrons from the cathode, whether photoelectrons or thermionic in origin, are multiplied to give an output current linearly proportional to cathode current, until the voltage across the tube gives a gain so high that feedback from anode to cathode occurs, and the limiting gain thus defined depends on the tube design, but varies from about 10^7 for box and grid, to 10^9 for venetian blind. In all cases, how-

TABLE 2
CHARACTERISTICS OF VACUUM AND GAS PHOTOCELLS AND PHOTOMULTIPLIERS

Cathode Type (a)	Cathode Sens'y (Amps per lumen × 10^{-6}) S	Cathode Area (cm²)	Cathode Av. dark current at 20 °C (Amps × 10^{-12})	Type	Gain G	Max. anode dark current (Amps × 10^{-6}) I_D (h)	Equiv. light power (lumens) I_D/GS	Equiv. light noise (lumens) $\sqrt{(2eI_bG\Delta f)}/GS$ (c)	Typical anode load (Ω) R	Johnson noise (equiv. lumens) $\sqrt{(0\cdot1e\Delta f/R)}/GS$ (c)
S4	50	2	10^{-2}	vac.	1	0·05	10^{-3}	3×10^{-9}	10^7	10^{-9}
S1	20	3	20	vac.	1	0·05	3×10^{-3}	3×10^{-9}	10^7	10^{-9}
S11	30	10	5×10^{-3}	vac.	1	10^{-7}	3×10^{-12}	6×10^{-12}	10^{11}	10^{-11}
S4	30	4	—	gas	10	0·1	3×10^{-4}	6×10^{-10}	5×10^6	2×10^{-10}
S1	12	4	—	gas	10	0·1	8×10^{-4}	2×10^{-10}	5×10^6	2×10^{-10}
'S'	40	1	3×10^{-5}	mult.	10^8	10^{-2}	3×10^{-12}	2×10^{-13}	10^8	4×10^{-18}
S11	70	15	6×10^{-3}	mult.	10^7	0·1	2×10^{-10}	2×10^{-12}	10^6	2×10^{-16}
S1	20	15	100	mult.	10^6	20	10^{-5}	3×10^{-9}	10^4	10^{-12}
S20	170	15	10^{-3}	mult.	10^6	10^{-2}	5×10^{-11}	3×10^{-13}	10^6	10^{-15}

Notes: (a) S1 cathode is AgO-Cs; S4 is SbCs, opaque; S11 is SbCsO, semi-transparent; 'S' is E.M.I. low dark current SbCs; S20 is Sb, NaK, Cs.
(b) Anode dark current I_D is specification maximum, including leakage.
(c) Figures are for a bandwidth Δf of 1 c/s.

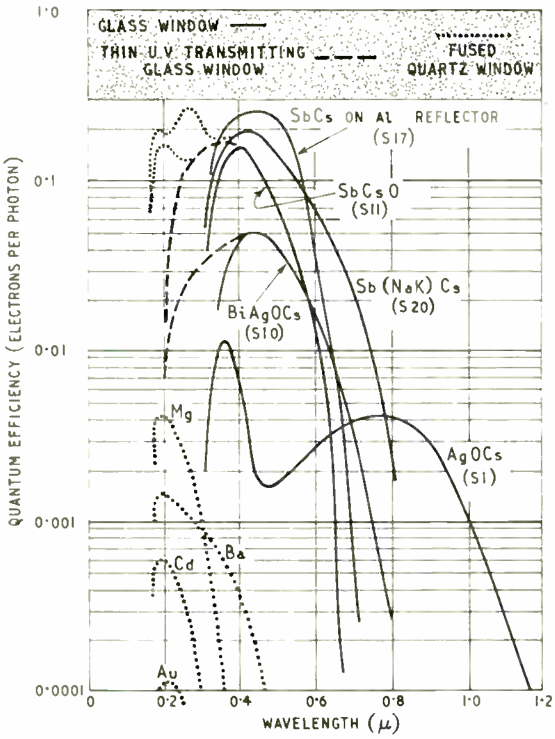


Fig. 4. Spectral response of various photo cathodes

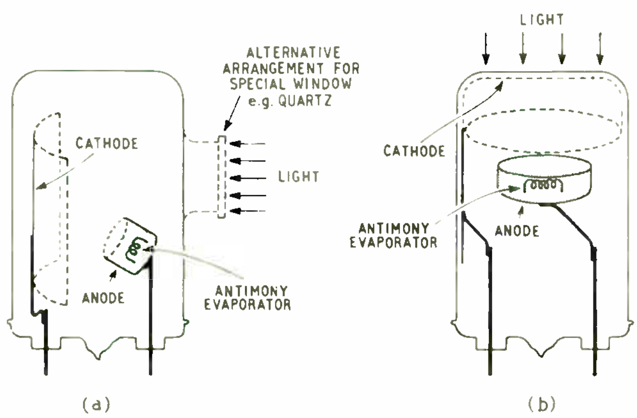


Fig. 5. Two ways of forming a photo cathode are shown here. At (a) the cathode is of opaque construction, at (b) it is semi-transparent. For convenience, the anodes can incorporate an evaporator for the deposition of a component of the photo cathode: e.g., Sb

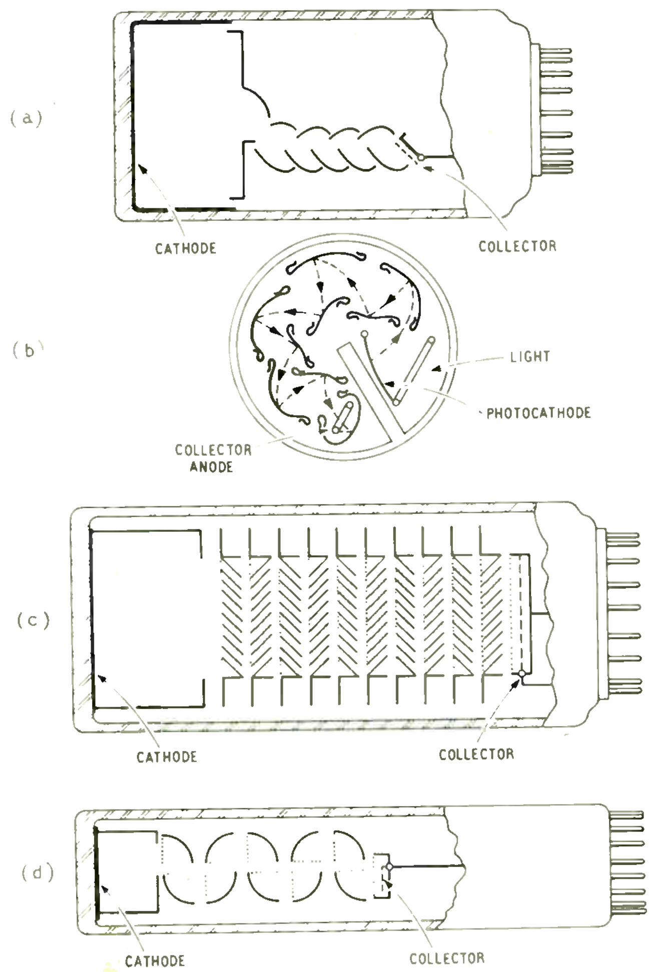


Fig. 6. Various forms of electrostatic dynode systems are sketched here. At (a) is a focused structure, while (b) shows a compact focused structure; (c) illustrates the 'venetian blind' arrangement and (d) a 'box-and-grid' structure

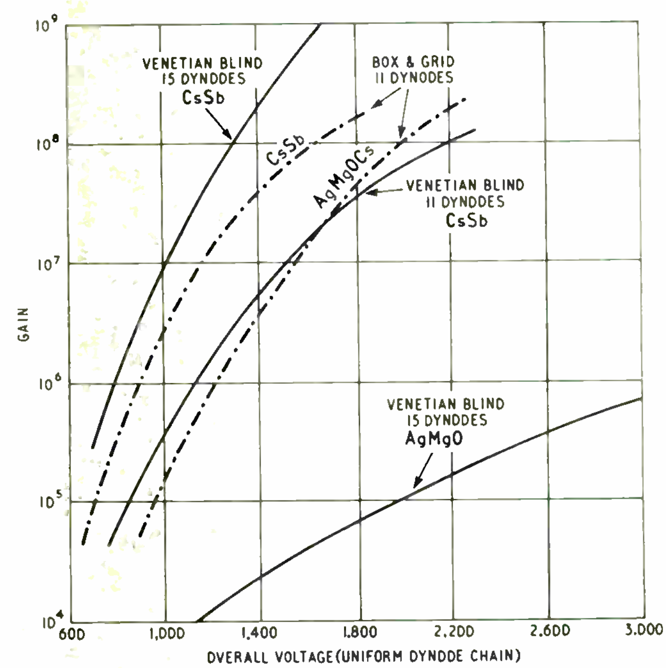


Fig. 7. These curves show the variation of gain with overall voltage for various dynode systems in photomultiplier tubes and for different secondary-emitting surfaces

ever, p.m. tubes are able to give a gain high enough to make shot noise the limiting factor in wide bandwidth measurements (Table 2).

P.m. tubes, as shown in the photograph, are made in a range of sizes, from $\frac{1}{2}$ in. to 16 in., and with four basic cathode types, namely SbCs; Sb-NaK,Cs; Bi,AgO,Cs; and AgO,Cs, but a number of others is also employed. The ability of p.m. tubes to operate right down to the fundamental shot-noise limit makes them suitable for television flying-spot film machines, while their low dark current is of great importance in spectroscopic apparatus. Their high gain and fast response has, in addition, created applications, such as the scintillation detection of low energy nucleonic particles, which would otherwise be impossible.

The whole range of photoemissive cells has a fundamental upper temperature limitation of about 60 °C when caesium is used, although the bi-alkali surface, NaK-Sb can be used up to 150 °C, while the lower temperature limit is between −80 and −180 °C. Very good rugged-ization can be achieved, and p.m. tubes capable of withstanding accelerations of 50 *g* over the range 20 to 2,000 c/s are available.

The three broad classes of cell discussed here are the vacuum type, the gas-filled type, and the vacuum with a built-in electron multiplier, that is, the photomultiplier. As already mentioned, they each have their own sphere of application. The uses of the vacuum type are now mainly the measurement of light intensity. The gas type is not very suited to this and its use is now largely confined to the sound heads of ciné-film projectors. Apart from its television applications, the photomultiplier tube finds much use in the nucleonic field and is even employed in astronomy—for the measurement of the light intensity from stars.

There are further classes of photocell which are very important in industry. These are the solid-state or semiconductor types and these will be described in a further article.

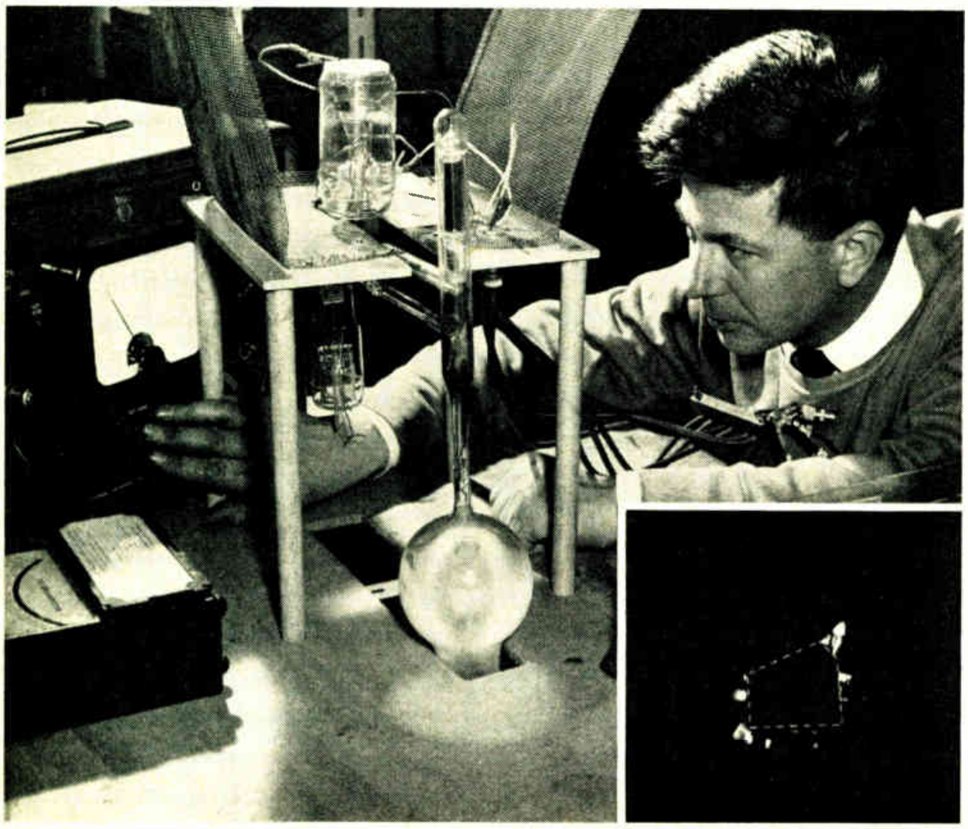
Acknowledgments

Figs. 1, 4, 5, 6 and 7 are taken from a paper by the present author, published in *Electronic Technology*.

Material provided by E.M.I. Electronics Ltd. and Mullard Ltd. has been consulted in the preparation of this paper.

ELECTRON EMISSION FROM SEMICONDUCTORS

The use of a reversed-biased p-n junction in a valve in place of a thermionic cathode is being investigated at The Hirst Research Centre of the General Electric Co. Ltd. An obvious advantage is the great reduction in the cathode power supply for the reverse bias should consume less power than a heated cathode. It is expected that it will prove possible to obtain very high current density.

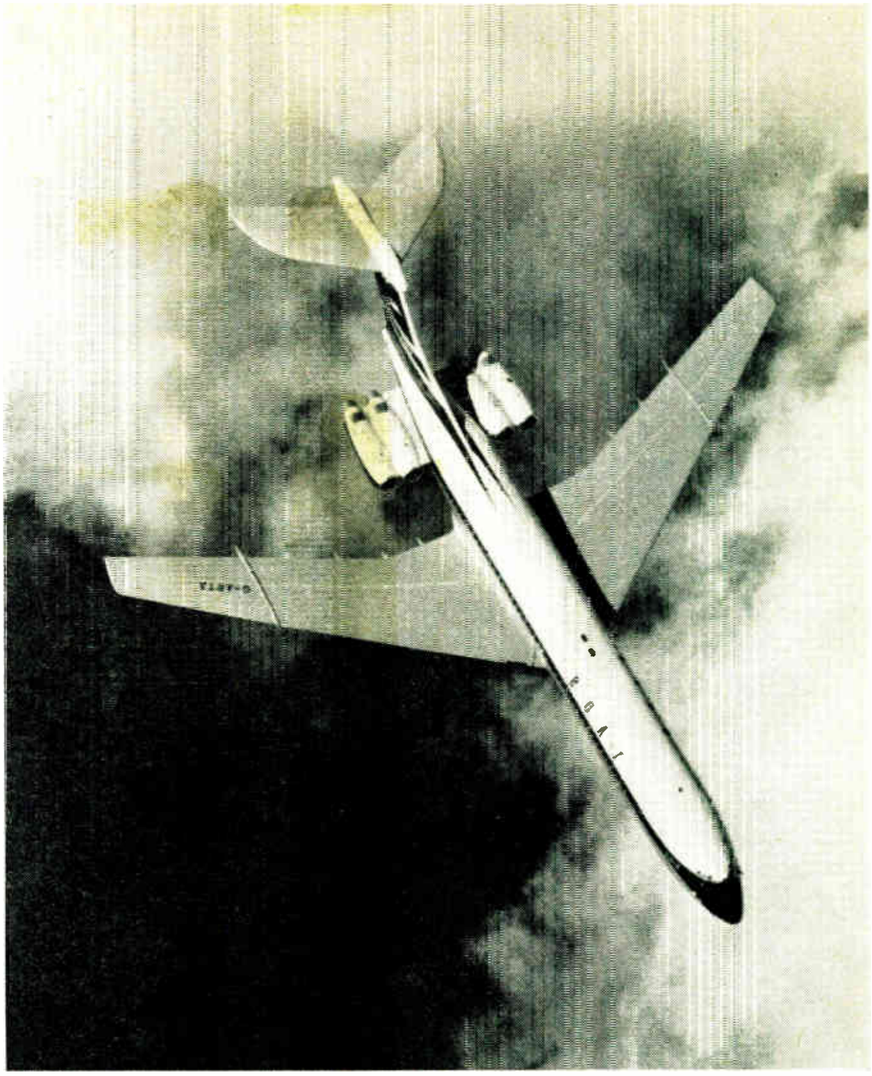


The high electric field which exists in a reversed-biased p-n junction produces energetic electrons and some have sufficient energy to be emitted into a vacuum. Silicon junctions have been developed with a thin n-type layer on a p-type base. Because of the thinness of the n-type layer electron emission can occur over the whole area.

Silicon-carbide grown junctions, however, give emission only from the periphery. The inset to the photograph, which shows experimental work on the new cathodes, illustrates the electron-emission pattern imaged on a fluorescent screen. The dotted lines indicate the outline of the crystal.

So far currents of 30 μA have been obtained, but there is no reason to suppose that this is the limit. It is a small current, but it is enough for some applications and it is expected that further development will enable the current to be increased.

Simulators are being increasingly used for training purposes because they are cheaper and safer than using real aircraft. Efforts are continually being made to improve the degree of simulation and in this article is described the latest development, a colour picture of an airfield viewed by a colour television camera under the control of a computer.



The VC-10 airliner

FLIGHT SIMULATORS

A SIMULATOR is basically a device which imitates the performance of some other device. It is a form of analogue computer which provides outputs which, instead of being in numerical form are of the same kind as the real device. A simulator is normally used for training purposes because it is cheaper or safer to train an operator with a simulator than with the real device.

One example is in training air-traffic control personnel. In this case, the trainee has a normal radar display unit. However, the echoes which appear on it to represent aircraft in the vicinity are not signals from real aircraft. They are pulses generated in a simulator under the control of an instructor. He turns knobs on this instrument and it produces output signals which simulate those which real aircraft would produce in the operational system. A factor of special importance here is the ease with which emergency procedures can be taught, for the instructor can set up dangerous conditions, such as 'aircraft' on a collision course, in a way which would be quite inadmissible in reality.

This is a relatively simple example. Much more complex is a simulator for pilot training. The aim here is to have a full-scale model of the cockpit of an aircraft complete with instruments and controls. Not only must all the instrument readings vary correctly with control movements as they do in the real aircraft, but the whole cockpit must so move that the pilot has the same feeling of movement as he would have in the real aircraft. Ideally, too, he would be able to see a coloured moving picture of the normal view ahead; this is especially important during 'take-off' and 'landing'.

Although the cost of such an elaborate simulator is naturally considerable, so is the cost of flying a large modern aircraft. With the simulator the bulk of a pilot's training can take place on the ground and he can have many hours 'flying time' very cheaply.

The modern flight simulator is a descendant of the early Link trainers, conceived and built by Ed. Link in the U.S.A. Various trainers were built during the War for the Royal Air Force and the United States Air Force. Among these were the elaborate celestial Link trainers, the Silouth trainer and the mechanical computing simulators built by R.A.F. personnel at St. Athans for some of the war-time bombers.

Fixed-Base Simulators

The first simulator recognizable as belonging to the modern family was designed by Dr. Dehmel for the Boeing B377 Stratocruiser and it was built by Curtis Wright for Pan American Airways. A second simulator, also for the B377, was built for B.O.A.C. in this country by Redifon ; this firm also built the first jet transport aircraft simulator for the Comet 1.

The first B377 simulator went into service in 1948 and subsequently others were developed for other aircraft and were widely used. With them the aircrew not only learnt cockpit drills and the procedures for engine and systems handling but carried out these procedures and emergency drills while 'flying' the simulator to maintain a correct course as laid down by simulated radio aids. These early trainers were fixed base ; that is, the cockpit was stationary and gave the crew no sense of motion.

Movable-Base Simulators

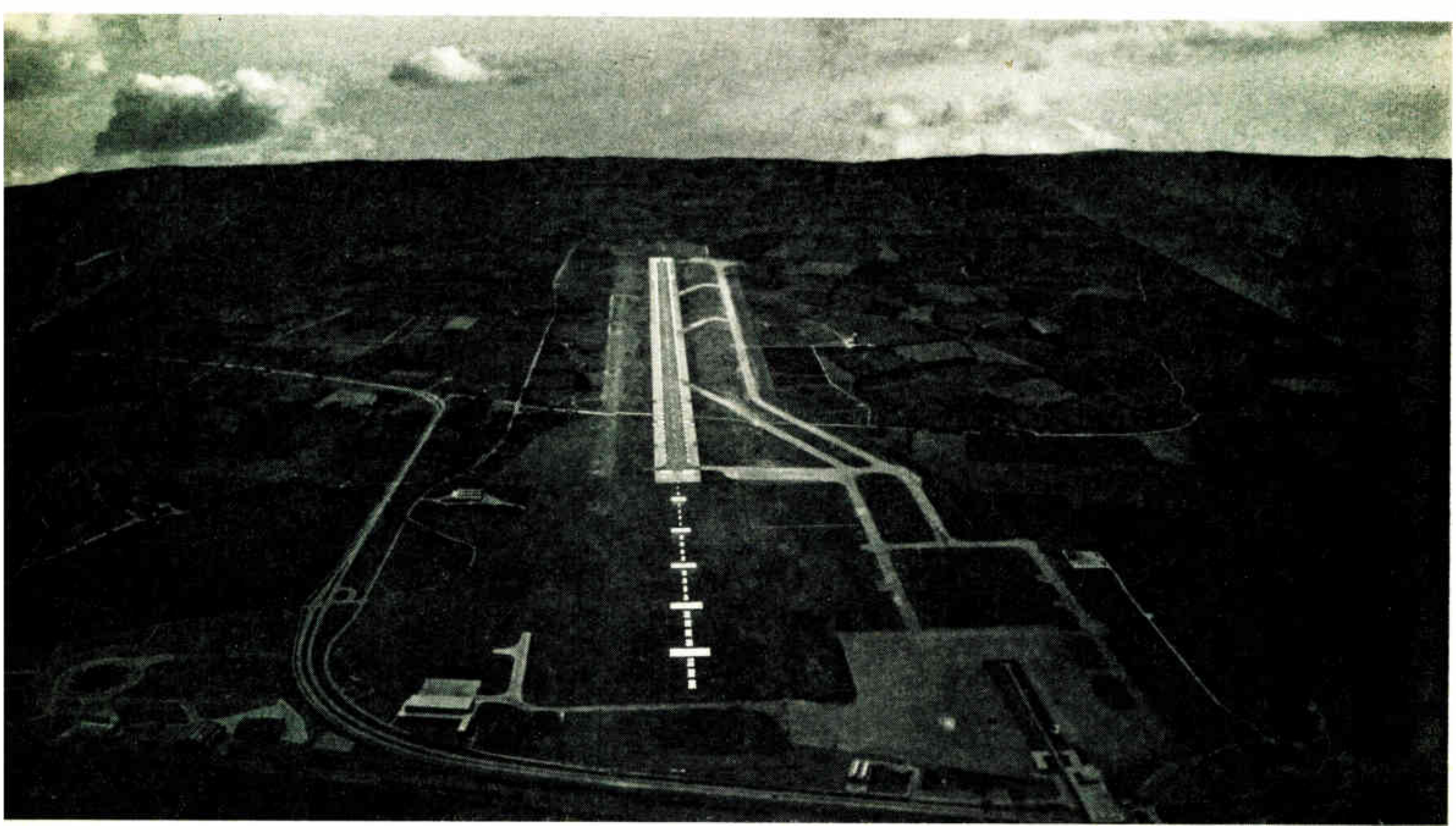
With fixed-base units simulation was not complete for, in fact, a pilot gets a lot of information almost unconsciously from the 'feel' of the aircraft. It is highly desirable that the cockpit should move in such a way that to the pilot the movements feel like those of the real aircraft. As the need for this became appreciated, aircraft themselves were increasing in complexity, and the demands on the simulator consequently increasing. It was necessary to bring in cabin pressurization, hydraulics, power plants and so on, and to improve the accuracy of flight computation. At the same time, with the increasing flying costs, the importance of a simulator for training was getting greater.

These improvements have all proved possible and are found in modern simulators. It is in computer techniques and components and in hydraulic components that the more important developments have taken place. Motion of the cockpit in three axes can now be obtained, giving a rotation in pitch, a vertical component of acceleration and a lateral component of side forces and some aspects of roll. Unless such physical cues are provided the pilot is dependent upon watching his instruments at all times to maintain his correct course, attitude and altitude. In an actual aircraft, however, the pilot is subjected to acceleration cues which allow him subconsciously to check the aircraft's behaviour before reading his instruments for confirmatory information. Lacking such cues in a stationary simulator, the pilot must look to his instruments for initiating information which, of course, is unrealistic ; also it necessitates the use of incorrect damping of the simulator if the pilot is to fly it in a satisfactory manner. Modern movement systems are of sufficient magnitude and controlled by sufficient power to provide the acceleration cues in phase with the computer, even though the simulator fuselage with the crew in it may weigh as much as two and a half to three tons.

Visual Aid

Even with such provision of the acceleration cues, which are sometimes related to the pilot 'flying by the seat of his pants', there is still the final external visual scene missing from the flight simulators. It is true to say, however, that at all times, even back in the days of the very early Link trainer, circa 1936, everyone has said

View of airfield in half-light showing the runway and approach lighting



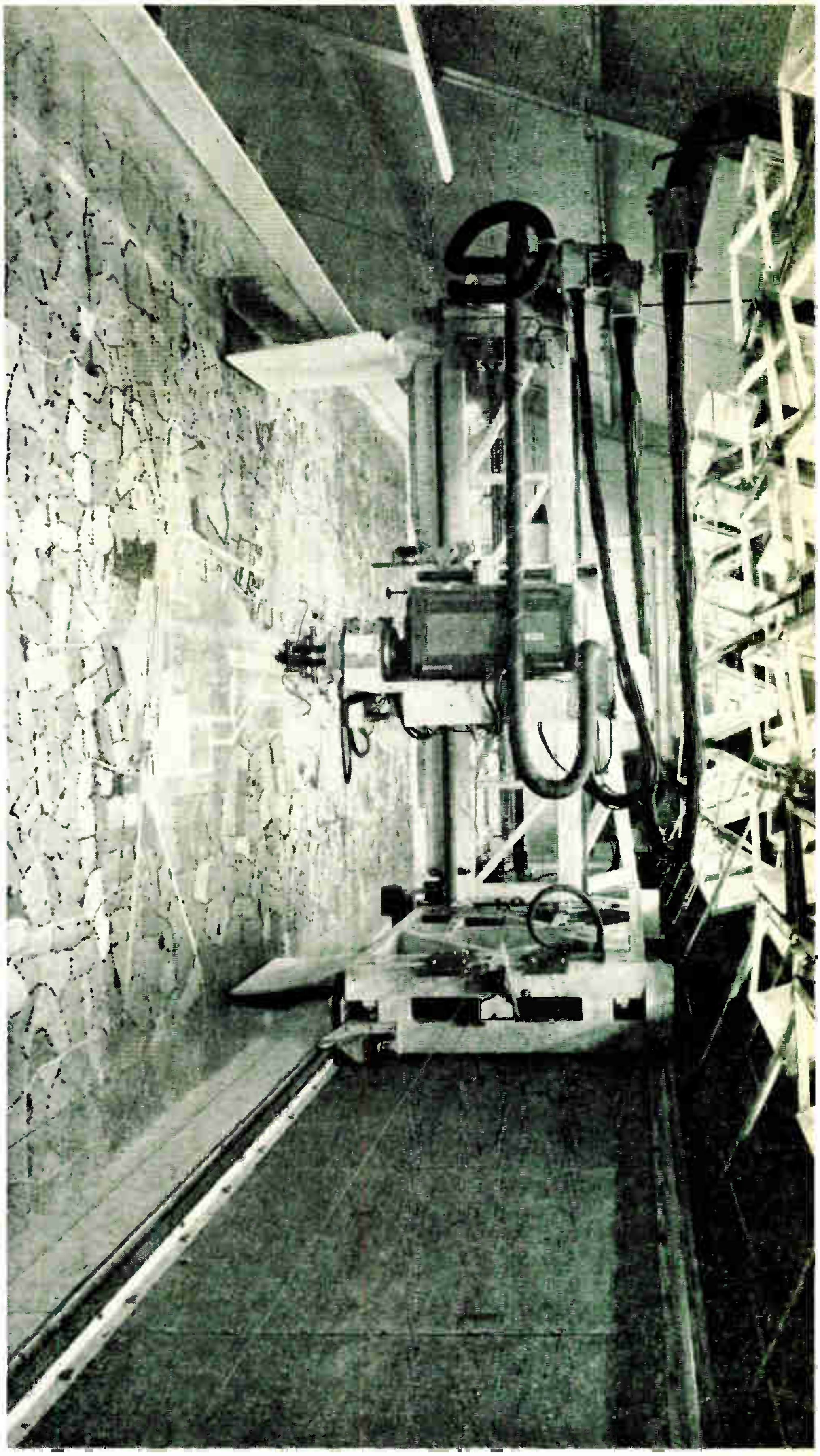
'Wouldn't it be nice if only we had a visual system or projection of the airfield so that we would land under visual contact conditions'. Until recently the problems of providing such visual pictures have been prohibitive both with regard to price and to a satisfactory manner of faithfully reproducing the outward scene so that at all times the pilot sees it as he would in real life. Various suggestions were put forward, such as using film with appropriate correction, but all such devices, since they were already recorded history, suffered severe limitations if the pilot deviated from the very narrow segment of approach. With the availability of television cameras and projectors, however, it became possible to control television cameras with respect to a three-dimensional model of an airfield so that the camera sees the scene in the same way as would a pilot looking out through the windscreen of his aircraft.

Redifon Ltd. in its approach to the subject, decided that the only medium in which to present such a picture was to use a three-dimensional model correctly coloured, a colour-television camera and associated colour projectors. After some years of development, during which a suitable lens was designed and developed, this has allowed them to produce a visual system for attachment to flight simulators which allows the pilot not only to make his approach and flare-out, but actually to land on the runway and taxi as he would in real life. Similarly, he may line up prior to take-off and carry out his take-off run and climb within the limits of the model, again as he would in real life.

Monochrome or Colour?

The decision to use colour rather than monochrome was influenced by the two major factors of recognition, namely that a person determines what a particular object is by both shape and colour, and if he is to forfeit colour a greater period of time must be taken to come to his final conclusion. While under approach conditions of approximately 135 knots, the pilot has adequate time to make this recognition if he is not subject to any other problems and if he is on the proper glide slope and correct runway course. Experiments, however, have proved that if the pilot is not in this favourable condition it will take him a considerably longer period to establish himself correctly or to regain the proper position when carrying out his approach with a monochrome projector picture as against doing the same task in natural 'true to life' colours.

B.O.A.C. after some considerable



Television camera in front of the airfield model. Movement of the camera on its housing from front to back of the picture corresponds to an aircraft approaching the runway to land

Control console and monitor tube for the visual approach simulator

testing of the Redifon system, have ordered this visual aid for attachment to two VC-10 simulators which are also being made for the Corporation by Redifon. The time sharing of the single camera and model is carried out by automatic switching circuits under the control of the simulator instructors, each simulator having its own projector and screen in front of the appropriate pilot. In this way the two simulators will share one airfield in much the same way as two separate aircraft will land and take-off in appropriate sequence according to the instructions of the control tower. The Redifon colour visual system is scheduled to go into training operation with the first VC-10 simulator at the beginning of July, 1963.

The equipment can be supplied as an integral part of new installations or as a modification to existing equipment. It consists of a full-colour closed-circuit television system and a three-dimensional coloured model of an airport and the surrounding countryside. As the pilot flies the simulator, the television camera is automatically controlled so that the correct aspect of the scene is viewed and the resultant 'picture' is either projected on a screen in front of the pilot by means of a colour television projector, or else shown to him on a 21-in. direct-vision colour television tube mounted in front of the flight-deck windows. The result is an entirely natural and convincing impression of landing and take-off, aided by the acceleration and aural cues provided in the existing simulator. The cover picture indicates the effect obtained.

Lighting and visibility are infinitely variable from day to night and from clear visibility to extreme cloud base and/or fog conditions. It will be appreciated that under night conditions only a system utilizing colour can show the runway lights and approach lighting bars in their appropriate colours. This applies still more with the almost universal introduction of VASI RED/WHITE visual landing aid, which is fully simulated in the Redifon system.

This development emphasizes the considerable advantages and economies already existent in simulator usage, compared with the use of actual aircraft for initial, elementary, procedure, conversion and other aspects of flight crew training. Quite apart from the saving of the enormous expense involved in using training aircraft or directing operational aircraft for training purposes, full-flight simulators with visual indication enable pilots and crews to become experienced in the handling of emergency conditions (and, indeed, to make all kinds of mistakes in the training process) without danger or damage to the equipment and without danger to life or limb.

The way in which all this is effected cannot be described in detail, for it would take quite a large book to do so! Basically, the simulator is an analogue computer which performs all the usual mathematical functions of addition, subtraction, multiplication, integration and function generation. It operates on the basic aerodynamic equations to compute what the aircraft would do under the particular conditions existing. Its outputs represent this and are used to control servomechanisms and hydraulic systems which produce in the cockpit not only the appropriate instrument reading but the proper 'feel' to the pilot.

For example, if in the real aircraft the pilot moves a control to make a turn the control will offer a certain resistance to movement which will depend in part upon the airspeed and any cross wind. In the simulator the trainee must experience that same resistance and so the control must have a variable loading controlled appropriately by the computer. In the real aircraft, the pilot will feel the aircraft turn; that is, he will experience various forces. In the simulator, the cockpit must be moved in such a way that the trainee experiences very similar forces. The cockpit must thus be moved in the required way at the proper rate by servomechanisms operating under the control of the computer, which has first to work out what these must be! With the visual aid, the model airfield and television camera must move relatively so that the television picture corresponds. Again, the computer works out what must be done and provides the necessary output signals to control the camera system and carry out the movements.

For further information circle 44 on Service Card

Teleprinter School

IN a modern railway system, where fast-moving trains must be matched by a rapid, reliable and highly efficient means of transmitting written messages, good communications are of vital importance. Speed and accuracy are essential not only for operational messages, but also for important communications such as those giving details of customers' special requirements, etc.

To meet these needs, the London Midland Region of British Railways are to install a fully automatic electronic telegraphic switching system which is built around the Standard Telephones' 'Strad' equipment. 'Strad' is short for Signal Transmitting Receiving and Distribution and, in this application, it receives teleprinted messages and relays them automatically, at a speed of up to 66 words a minute, in priority and time order to one or to any number of addresses. Messages can also be stored in the system and relayed to destinations at a later date or at any selected time.

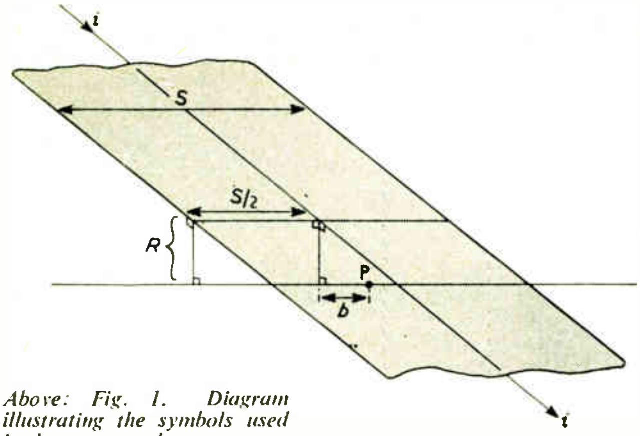
The system does not give direct point-to-point contact between sending and receiving stations; messages are directed to their destination(s) by routing codes, teleprinted at the top of the message by the originating operator.

The London Midland 'Strad' system, which will be one of the first of its kind in commercial use, is to be installed in three stages: stage 1 covers the connection of 33 existing telegraph offices to the 'Strad' centre which is now being installed at Crewe. Stage 2 is planned to extend the system to include the existing commercial teleprinter network at present centred on Birmingham; and stage 3 covers the connection of the system to other main offices.

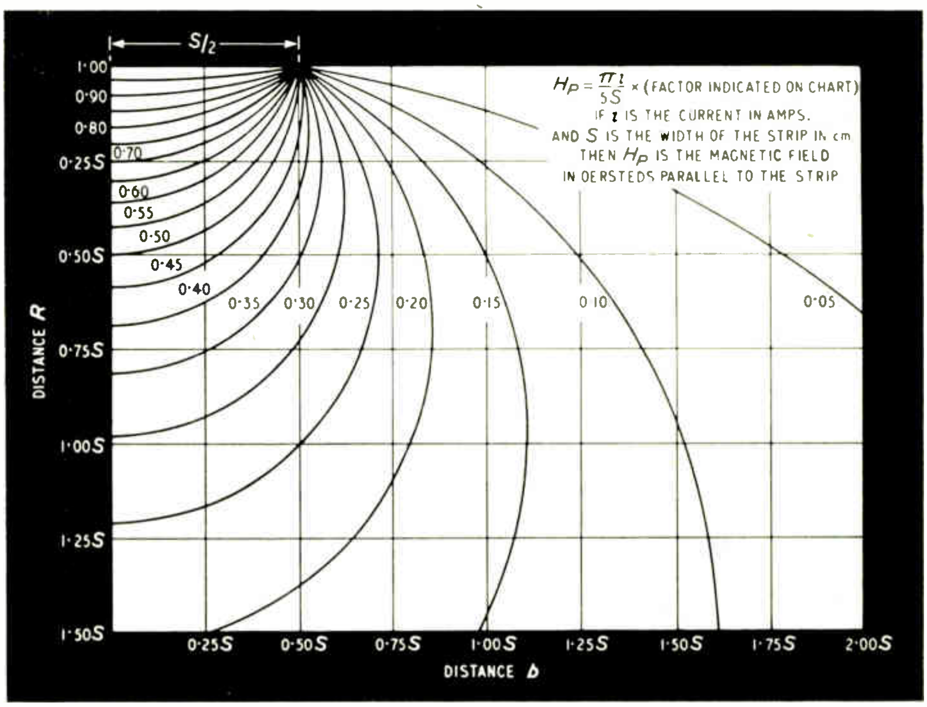
As the efficiency of this system depends to a very great extent upon a high standard of teleprinter operation a school has been established at Hendon to provide training in teleprinter operation. This school will run two types of course. The first, a short course of one or two weeks for railway staff at offices to be connected to the 'Strad' network, who are already experienced in teleprinter operating but require instruction and practice in the 'Strad' procedure. Secondly, a six-week course for staff who have no knowledge of teleprinters.

This shows a number of trainees practising teleprinter operation in one of the classrooms at the British Railways' teleprinter school at Hendon

MAGNETIC

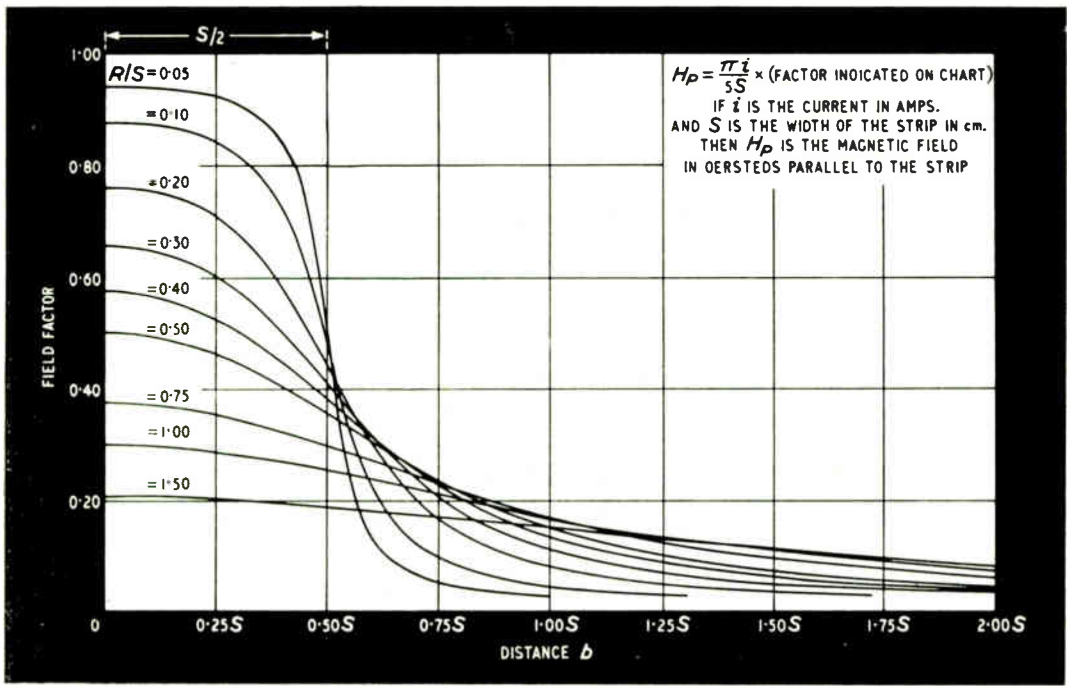


Above: Fig. 1. Diagram illustrating the symbols used in the nomograph



Right: Fig. 2. Nomograph for calculating the parallel component of the magnetic field due to a strip conductor

Below: Fig. 3. Distribution of the parallel component of the magnetic field due to a strip conductor



FIELD NOMOGRAPH

By N. D. RICHARDS, B.A., M. J. TAYLOR, B.A. and G. WINSOR, B.A.*

Describes a graphical way of determining the magnetic field produced by current in a strip. This is a problem which must often be solved in designing some kinds of stores for computers.

IN the design of printed circuitry for use with matrices of thin magnetic films, it is frequently necessary to calculate the distribution of the component of magnetic field in the plane of the film when a current is passed down a strip conductor above the film. Calculation of this distribution may prove tedious and for this reason a nomograph has been prepared which enables the field distribution to be obtained simply and rapidly.

If the strip is of width S and of negligible thickness, and R and b refer to the co-ordinates of P the point under consideration (Fig. 1), then the component of magnetic field at P parallel to the plane of the strip is given by:—

$$H_P = \frac{i}{5S} \tan^{-1}\left[\frac{SR}{R^2 - \frac{S^2}{4} + b^2}\right]$$

where, if S, b and R are in cm, and i is in amps, then H is given in Oersteds.

It may be shown that the angle in the foregoing expression is, in fact, the angle subtended by the strip at the point P. It follows that any circle of which the strip forms a chord is a locus of points of equal parallel field. The nomograph of Fig. 2 consists of a family of such circles which have been drawn for equal increments of this angle expressed as decimals of π. This nomograph may be used to calculate the parallel component of magnetic field at any point in the vicinity of the strip.

In order to determine the distribution of the parallel component of field in a plane distant R from the strip, the distance R must first be expressed in units of the strip width S, and a line drawn on the nomograph parallel to the strip at a value appropriate to this normalized distance. At each point at which this line intersects one of the circles on the chart, the value of field is given by the 'field factor' appropriate to that circle. By measuring the distances from the vertical axis at which the line in question cuts each circle on the chart, the distribution of the 'field factor' at a distance R from the strip may be obtained. Fig. 3 shows the distribution obtained for a number of suitable values of R/S.

* Mullard Research Laboratories.

R.E.C.M.F. EXHIBITION, BASLE

The British Electronic Component & Instrument Exhibition which was held in Basle, Switzerland, from the 15th to 20th October is the first of a series of exhibitions in which the British electronics and instrument industries plan to stage a comprehensive show in a different European city every year. The Exhibition was sponsored by the Radio & Electronic Component Manufacturers' Federation and included 52 companies. The majority of these were showing electronic components. Stand 56 was occupied by Iliffe Electrical Publications Ltd. and featured *Industrial Electronics*.

The total attendance figure for the week was 7,923. However, admission was by invitation only and most of the visitors were really interested in British products. Visitors included those from most countries in Europe, South Africa and U.S.A.

The general impression gained from the exhibitors was that the time spent at the show was worthwhile and that in most cases useful contacts had been made with Continental distributors and agents. Both the Germans and Swiss expressed their high regard for the quality of British electronic products and their surprise at the competitive prices quoted.

EQUIPMENT review

1. Digital Control Systems

A DIGITAL SYSTEM, by which the most complex controls are assembled from basic standard units, is announced by Lancashire Dynamo.

The system, for the application of electronic control to industry, is designed to ensure ease of understanding of even the most advanced installations. It has been developed to a high degree after three years of service, particularly in the steel industry.

Two other advantages are claimed: 1. Maximum flexibility because all the standard units are of an identical physical construction, plug into standard frames and use identical supplies and signals; 2. No routine maintenance is needed because of the absence of moving parts.

The same units are used for a wide range of industries and are applicable to industrial control, measuring, calculating, counting, sequencing and programming. Where additions to plant are required, the extension of an existing system is simple.

Systems can be used economically at all levels of complexity from simple static switching to complete programmed position and measuring controls.

The company has expanded its Digital Systems Division to provide customer advice and to prepare proposals for the solution of individual problems.—*Lancashire Dynamo Electronic Products, Rugeley, Staffordshire.*

For further information circle 1 on Service Card

2. High-Speed Dry-Reed Relays

INCLUDED in a new range of dry-reed relays introduced by Erg Industrial Corporation, are four basic types—standard, double throw, heavy duty and miniature. All are very compact and are electrically operated at speeds down to less than 1 msec without coil lag. The contacts are hermetically sealed in an inert gas atmosphere so ensuring complete freedom from contamination. The whole is then encapsulated as proof against adverse climatic conditions and with a high surface resistance between coil and leads.

Now available are some 15 variants of the four basic types, giving a wide and versatile range from which can be selected types for many purposes. Special layouts are available for low leakage applications and for special systems of operation.—*Erg Industrial Corporation Ltd., Luton Road Works, Dunstable, Beds.*

For further information circle 2 on Service Card

3. Angular Motion Transducer

A COMPACT angular motion transducer which produces high d.c. output voltage for small angular deflections from zero to 18 degrees is available from Aveley Electric.

Manufactured by Brush Instruments and designated Metripak model 33 01, the unit is one of a series offered as basic building blocks for use in control, weighing, instrumentation and similar systems. The series includes units for a.c. or d.c. operation with a.c. or d.c. outputs, and is based on

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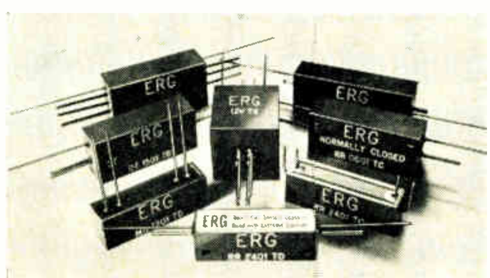

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incorporation of a carrier-excited high-output sensing element in the same package with all the electronics required to operate it.

The Metripak model 33 01 operates on 115 V r.m.s., 60 c/s, and produces a minimum output of 0·6 V d.c. per degree of shaft rotation. Included in the compact package are a sensing element, power supply, precision oscillator and phase-sensitive output demodulator. Electrical specifications, characteristic of the basic Metripak series, are:—(1) stepless resolution; (2) 0·01% repeatability; (3) linearity 0·1% at 10 degree shaft position into a 100-kΩ load. Reactive force, exclusive of bearing stiction is negligible. Temperature stability is 1% over a 100 °F range and 2% from −40 °F to 160 °F. A 10% change in input voltage will produce a change in output of less than 1%.

Angular motions to be measured are connected directly to the input shaft. The shaft is an integral part of the sensing element and does not require cams or linkages to translate rotation. A precision boss concentric with the shaft assures accurate alignment with associated positioning device. A special mounting plate is available for flange type installations. Input shaft may be supplied with either precision ball bearings or flexure pivots, or units can be provided without bearings and shaft, permitting direct coupling with user's shaft.

The dimensions of the Metripak Model 33 01 are 3 $\frac{3}{16}$ in. × 2 $\frac{3}{16}$ in. × 1 in.; total weight is 7 oz.—*Aveley Electric Ltd., South Ockendon, Essex.*

For further information circle 3 on Service Card

4. Solid-State Current Regulators

CIRCUIT DYNE CORPORATION, of U.S.A., have announced two new series of 'Currector' current regulating devices, an 800-mW high-temperature silicon series, and a 350-mW series featuring low minimum operating voltage.

These current regulators are two-terminal, solid-state devices that limit current much as zener diodes limit voltage. Both of the new series are available in fixed current ratings of one to twenty milliamperes in 5% increments.

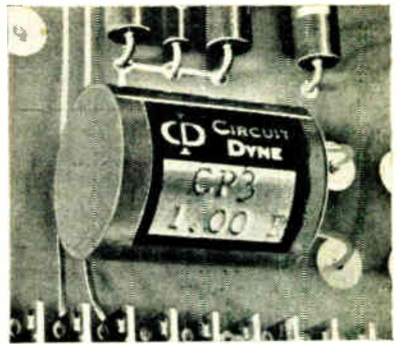
The CP2 and CN2 silicon series have an operating temperature range from −55 °C to 125 °C with controlled regulation to 40 V. The CP2 is a polar version, and has a reverse characteristic similar to that of reverse-biased silicon diode. The non-polar CN2 has identical forward and reverse characteristics.

CP3 and CN3 'Currectors' have typical minimum operating voltages as low as 2 V, with current regulation closely maintained up to 25 V. Operating temperature range for the series is −55 °C to + 85 °C.

Both new series feature current regulation of typically ± 1% over their operating voltage ranges, low shunt capacitance, and low temperature coefficient of current. They can be used advantageously in many designs, providing the engineer with a significant means of circuit simplification. Typical applications of the 'Currector' include timing and squaring circuits, pulse integrators, differential amplifiers, sweep circuits, multivibrators and power supplies.

The new series are epoxy encapsulated and are available with axial or single-ended leads and are distributed by: *Sylvan Ginsbury Ltd., 8 West 40th Street, New York 18, New York, U.S.A.*

For further information circle 4 on Service Card



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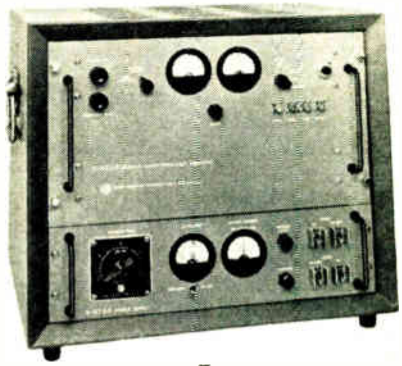
5. Rubidium Vapour Frequency Standard

VARIAN AG are now able to offer a portable frequency standard, based on the Rubidium 87 Hyperfine transition, with long-term stability of the order 5 parts in 10^{11}.

Two of these instruments type X4700 were checked against each other and the U.S. Frequency Standard, and the results published weekly over a period of several months. An analysis of the performance during this period indicates a stability of 5 × 10^{-11} over a one year period and a short term stability over a one second averaging time of 1 × 10^{-11}.

Operating over a wide range of temperatures and humidities, the instrument combines the accuracy and stability of an 'Atomic' Frequency Standard in a rugged dependable and portable unit. Standard output frequencies are 5 Mc/s, 1 Mc/s and 100 kc/s simultaneously, but other frequencies are available to order.—*Livingston Laboratories Ltd., 31 Camden Road, London, N.W.1.*

For further information circle 5 on Service Card



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6. Improved Photoswitch

HIRD-BROWN are now marketing an improved version of their standard PS1 photoswitch, known as PS1M, in which a milliammeter is incorporated to aid the alignment of the light projector and receiver.

In this PS1M photoswitch the meter is connected to monitor the photocell current, which rises to a maximum when the light beam from the projector is aligned exactly with the photocell.

The meter can also be used to

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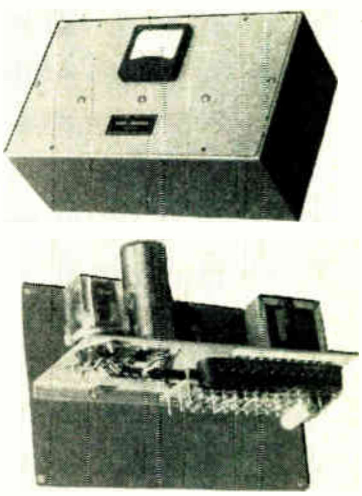


monitor the photocell current remotely to indicate that the light and the cell are working and also to indicate that the intensity of the light is normal.—*Hird-Brown Ltd., 244 Marsland Road, Sale, Cheshire.*

For further information circle 6 on Service Card

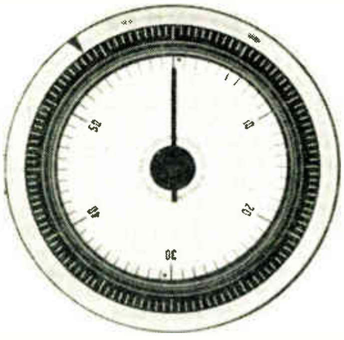
EQUIPMENT review

7. Automatic Timer

A DIAL-SETTING AUTOMATIC TIMER with four sets of change-over contacts is one of the latest units to be produced by Elremco.

This is the Super-Star type in which time setting is achieved by rotating a 4½-in. diameter bezel. Models are available with a wide selection of time ranges from 0–12 sec to 0–120 hr and for operation from most standard a.c. mains supplies. The switching action of the timer has two modes: first, the four sets of contacts can change over at the end of the pre-set timing period and, secondly, three sets of contacts can change over for the duration of the timing period. The switching capacity for each set of contacts is 5 A at 240 V a.c.—*Electrical Remote Control Co. Ltd., The Fairway, Bush Fair, Harlow, Essex.*

For further information circle 7 on Service Card



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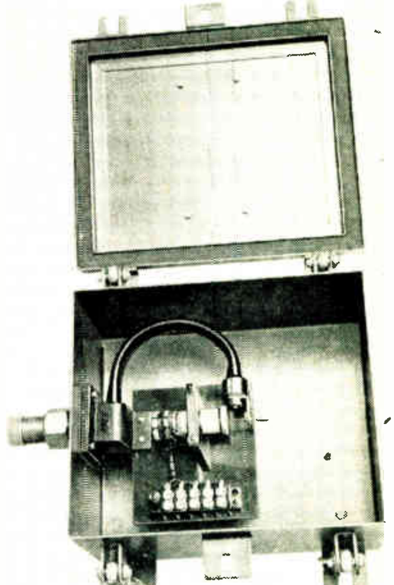

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8. Electronic Pressure Transmitter

FIELDEN ELECTRONICS have just introduced the most advanced pressure transmitter of its kind available to industry. It is offered in ranges from 0–50 p.s.i.g. up to 0–12,000 p.s.i.g. and produces a d.c. signal of 0–15 mA unaffected by line resistance, supply voltage variations, ambient temperature variations, a.c. pick-up, etc. The indicating instrument can be a normal moving coil meter and if required, several indicators and/or recorders could be used in series without affecting the calibration.

The complete transmitter consists of an electronic unit and a separate transducer which houses a bourdon tube and differential transformer. The two units have been separated so that the bourdon tube unit can be used in higher temperatures than the electronic unit and so that the electronic unit can be mounted in an accessible position whereas the transducer could be relatively inaccessible after installation. The movable core of the differential transformer is connected directly to the bourdon tube without any linkages or pivots and the user is not expected to make any adjustments at all.

The electronic unit has an oscillator operating at approx. 1,600 c/s which supplies the primary current to the differential transformer and this current is maintained constant irrespective of changes of the transformer primary resistance with temperature. The output voltage of the differential transformer is amplified and rectified to produce the output current and because of the very high input impedance of the amplifier changes in the resistance of the transformer secondary windings with temperature have no effect. Current feedback in the amplifier also ensures that the output current is unaffected by output circuit resistance.

Transistors are used throughout to improve reliability. To assist in servicing, a test-switch is fitted in the transmitter and both of the oscillator and amplifier cards can be replaced in less than one minute without any need for recalibration. — *Fielden Electronics Ltd., Wythenshawe, Manchester.*

For further information circle 8 on Service Card

9. Pressure Transducers

CONSOLIDATED ELECTRODYNAMICS have added three units to their current range of pressure transducers. These are all type 4-326 and are the Low-Range Transducer, the Low-Range Differential Transducer and the High-Range Differential Transducer.

The first measures gauge and absolute pressures from 10 to 100 p.s.i., the second has a pressure range ±10 p.s.i. to ±99 p.s.i., while that of the High-Range Differential model is from 100 p.s.i. to 5,000 p.s.i.

A most useful feature of the type 4-326 range is the provision for the adjustment of bridge balance, temperature compensation and sensitivity external to the strain-gauge sensing element, thus making it possible to set unusually close tolerances during manufacture.

All of the transducers will operate in temperatures ranging from −320 °F to +300 °F and are rugged and are usable in 1,000-*g* environments.

The spring-type, strain-gauge sensing element used is attached to the force-summing diaphragm. Pressure against the diaphragm produces a displacement that changes the resistance of the active arms. This then causes an electrical output precisely proportional to the applied pressure. Erroneous outputs caused by distortion or vibration are eliminated by the special stress

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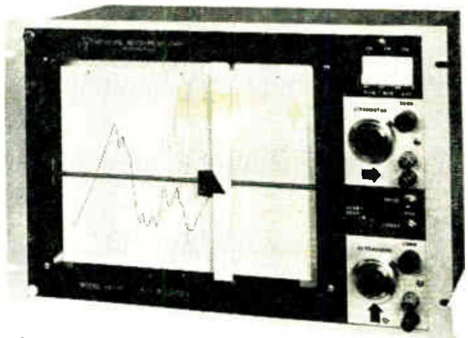

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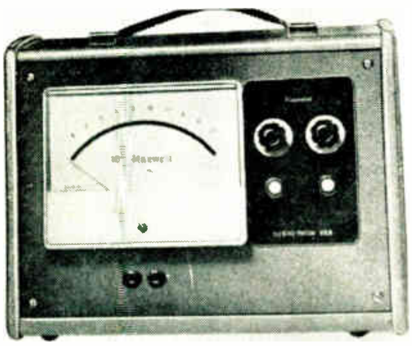

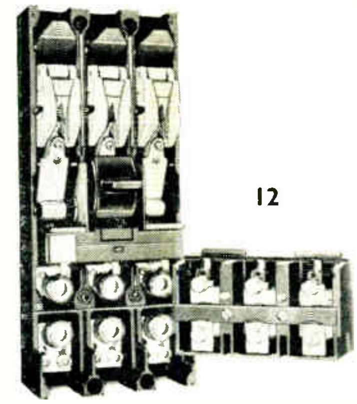

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isolation design. The four-active arm Wheatstone-bridge design of the sensing element has resulted in a symmetrical, thermally balanced unit. This symmetry and balance allow excitation voltages to 10 V, with a correspondingly high output of 40 mV.

Temperature, vibration and acceleration sensitivity have been minimized by this design feature, which provides close proximity of windings in the four-arm elements. The series meets high vibrational environments and has negligible response at 35 *g* peak.—*Consolidated Electrodynamics Corporation (U.K.) Ltd., 14 Commercial Road, Woking, Surrey.*

For further information circle 9 on Service Card

10. X-Y Chart Recorders

SCIENTIFIC FURNISHINGS are now able to supply two additional X-Y recorders which are produced by Houston Instrument Corp., U.S.A.

The first is Model HR-95T which has been designed with a built-in time-base and for use either in a standard 19-in. rack or, with a case, as a bench instrument.

The recorder features high performance servos, interchangeable plug-in control modules including timebase on X axis, standard zener reference supplies and 0·1% ten-turn attenuators on both axes.

It utilizes conventional vacuum system for holding standard $8\frac{1}{2}$ in. × 11 in. graph paper to a platen. A snap-in pen design utilizes standard recorder ink cartridges to eliminate ink-filling problems. A wide input range capability, with a d.c. accuracy greater than 0·25% full scale and pen speed of 15 in./sec are provided by this recorder.

A door assembly carrying the platen, pen carriage, servo motors and rebalance potentiometer swings out for ease of maintenance and adjustment. The servo amplifiers contain individual power supplies and are completely independent, isolated and interchangeable.

The second is Model HR-97 X-Y plotter. This is an addition to a line of accurate, reliable and inexpensive recorders. Housed in an attractive and usable bench case, it offers vacuum paper hold-down, zener references, 15 in./sec pen speed both axes, and over 600 in./sec^2 acceleration. Each axis is independent of the other with amplifiers that are interchangeable and contain independent power supplies. Maximum sensitivity of 1 mV/in. can be readjusted with a continuously variable attenuator for exact and known full-scale calibration. A combination of a snap-in pen that uses replaceable ink cartridges and a high-speed electric pen lifter allows point plotting up to 20 points/second.

A built-in time base is an optional feature. Sweep rates of 1·5 sec to 15 min full scale can be directly set with a continuously variable control. —*Scientific Furnishings Ltd., Instrument Division, Poynton, Cheshire.*

For further information circle 10 on Service Card

11. Fluxmeter with Amplified Damping

THE APPLICATION of the normal moving-coil fluxmeter to capacity, speed and magnetic measurements is limited by the instrument drift which frequently causes errors.

A fluxmeter is being marketed by Acru Electric Tool, which employs a double moving-coil system giving a damping effect to any drift which occurs. This damping action is electronically amplified and the resulting measurement is almost entirely free from drift.

This means that measurements over much longer periods can be taken ; i.e., the measurement of magnetic flux, field strength, the recording of hysteresis curves, etc., etc. Provision is made so that an X-Y recorder can be connected to the instrument. The delivery period for the fluxmeter is 5/6 weeks. —*The Acru Electric Tool Mfg. Co. Ltd., Acru Works, Demmings Road, Cheadle, Cheshire.*

For further information circle 11 on Service Card

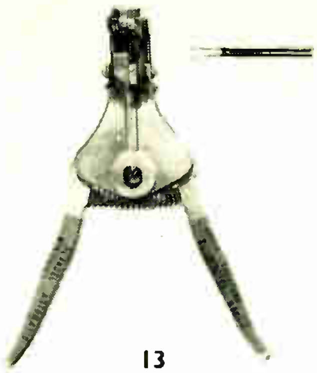
12. Tri-Pac Circuit-Breaker

A RANGE of AB De-ion moulded case circuit-breakers guaranteeing 2- and 3-pole protection at maximum interrupting ratings of up to 100,000 symmetrical r.m.s. amperes, has been introduced by Chilton Electric following the recent sales and manufacturing agreement signed with the Westinghouse Electric International Corporation of America.

The range of Tri-pac breakers features thermal time delay protection, instantaneous magnetic protection and current limiter protection—combined and co-ordinated in a single device.

Tri-pac breakers are suitable for use on low-voltage distribution systems of up to 600 V a.c. and 250 V d.c., where maximum current does not exceed

EQUIPMENT review



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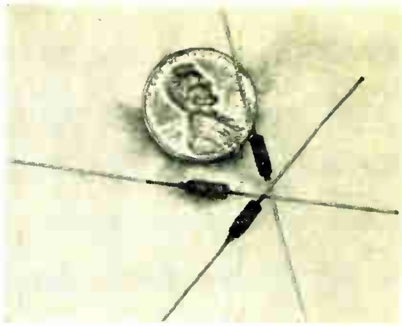

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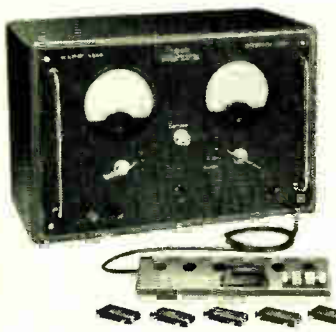

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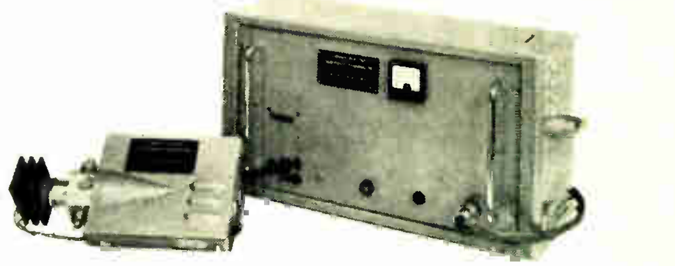

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600 A. They are designed for use in switchboards, control centres, panelboards, combination starters, bus duct plug-in units and separate individual enclosures.

A unique feature of the Tri-pac range is a specially designed current limiter. The limiter consists of either two or three silver link fuses which melt when abnormal fault currents above the nominal capacity of the instantaneous magnetic trip of the circuit-breaker are encountered, so opening the circuit. Simultaneously, the magnetic action of the breaker functions to open the contacts. When the silver links melt, a second wire also melts. In doing so, it releases a plunger from the pressure of a spring, so allowing it to be extended and to lock the trip bar in the unlatched position. Until the blown limiter is replaced, it is impossible to reclose the circuit. Further protection is provided by the inclusion of interlocks which prevent relatching of the breaker if the limiter is missing.

An additional feature of the Tri-pac range is the De-ion are quenchers which ensure that dangerous arcs are extinguished within half a cycle.

The breakers are available in various frame sizes, with current ratings of from 15 to 600 A and may be had in either two- or three-pole versions as standard.—*Chilton Electric Products Ltd., Hungerford, Berks.*

For further information circle 12 on Service Card

13. Twin-Wire Strippers

CREATORS LTD. have recently introduced a wire stripping tool which has been designed to remove easily the insulation from flat twin flex cable.

This hand tool, which is known as Model F2, accepts twin flat flex cable and separates and strips both wires simultaneously. It is suitable for 14/·0076 cable (and similar sizes) and can be used for stripping-off rubber or plastic insulation.—*Creators Ltd., Sheerwater, Woking, Surrey.*

For further information circle 13 on Service Card

14. Miniature High-Voltage Silicon Rectifiers

MOTOROLA SEMICONDUCTOR PRODUCTS are now supplying a range of subminiature, high-voltage silicon rectifiers. P.I.V. ratings up to 3,000 V are available and the mean current is 100 mA at 25°C. The rectifier is 0·27-in. long and 0·02-in. diameter with leads of 1-in. length.

Noteworthy features are a temperature range of −65 to +150°C and a forward voltage drop of 2·5 V (max). The range has the titles 1N3282 to 1N3286.—*Walmore Electronics Ltd., 11-15 Betterton Street, Drury Lane, W.C.2.*

For further information circle 14 on Service Card

15. Tunnel Diode Adaptor

A TUNNEL DIODE adaptor, to be known as the TD601, has been introduced by Wayne Kerr. It has been designed to be used either on its own or with the Wayne Kerr radio-frequency bridge B601. On its own, the tunnel diode adaptor provides all the facilities necessary for plotting the d.c. voltage–current characteristic of such diodes. Operated in conjunction with the B601 bridge, it enables the bridge to be used for measuring the conductance of tunnel diodes, in the positive and negative regions, together with the associated junction capacitance.

Suitable for measurements on germanium or gallium arsenide tunnel diodes, the TD601 is intended for operation at frequencies between 3 and 3·5 Mc/s when it provides a negative conductance range from −1·0 millimho to −50 millimhos (−1,000 Ω to −20 Ω) and will measure junction

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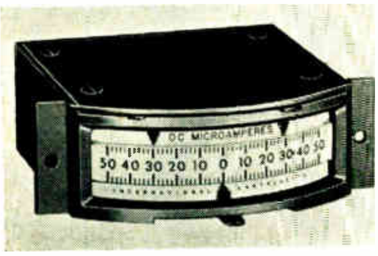


capacitances up to 5,000 pF. The d.c. metering facilities are 1, 5, 10 and 50 mA full-scale on one meter and 0·5 or 1·0 V full-scale on the other.

Both the meters of the control unit have an accuracy of ± 1% f.s.d. Variations in capacitance can be detected to better than 1 pF and at 100 pF the accuracy is ± 2%. At – 10 millimhos or higher the conductance accuracy is to within ± 3% and at – 2 millimhos the limit is ± 5%.

The control unit measures $13\frac{1}{4}$-in. wide, $9\frac{1}{4}$-in. high and $8\frac{3}{4}$-in. deep and the adaptor is $7\frac{1}{4}$-in. long, $1\frac{1}{2}$-in. wide and $1\frac{3}{4}$-in. deep. The control unit when containing the adaptor and resistor blocks weighs 12 lb.—*Wayne Kerr Laboratories Ltd., New Malden, Surrey.*

For further information circle 15 on Service Card

16. Thermoelectric Dew-Point Hygrometer

SALFORD ELECTRICAL are now manufacturing their MK. 2 thermoelectric dew-point hygrometer which makes continuous and automatic measurement of dew-points down to 30 °C below ambient temperature. One version measures the atmospheric dew-point and the other that of gases flowing in closed circuits. With gas temperature at 25 °C and pressure at 760 mm Hg the rate of gas flow through the hygrometer should not exceed two litres per minute. This rate may be increased at lower gas temperatures but should be decreased at above 25 °C.

These instruments are not recommended for use with halogens or corrosive gases. They are free from any calibration problems since they operate on the classical method; i.e., by detecting the formation of dew, and not on any transfer method. After installation, the hygrometers are virtually maintenance-free and only occasional cleaning of the mirror on which the dew is formed is required.

They can be operated on a power supply of 110 or 240 V at 50/60 c/s. Connections are made by plugs and sockets. Construction is in two units; the hygrometer head and the control unit. Solid state components are used throughout.

The control unit measures 24 in. × 12 in. × $9\frac{1}{2}$ in. and weighs 45 lb. The head measures $12\frac{1}{2}$ in. × $6\frac{1}{2}$ in. × $4\frac{1}{2}$ in. and weighs 5 lb. The maximum separation between the units is 6 ft.—*Salford Electrical Instruments Ltd., Peel Works, Silk Street, Salford 3.*

For further information circle 16 on Service Card

17. Radioactive Contamination Monitor

THIS TYPE PNI 1125 battery-operated portable instrument has been designed by Plessey to check whether radioactive contamination in bulk food supplies exceeds the maximum permissible (emergency) level (m.p.l.) for human consumption. It is currently being supplied in quantity to the Ministry of Agriculture.

All indications from the instrument are aural: clicks from the built-in loudspeaker indicate the presence of contamination, and when a preset alarm level is reached a continuous howl is superimposed.

The instrument uses a G-M tube normally sensitive to both beta and gamma radiations. In the case of food contamination assessment a simple calibration procedure allows the gamma contribution to be backed-off by the operator. This facility permits more accurate assessment of food contamination, as a beta check can be made on the sample under test, ignoring gamma radiation from other materials in the vicinity, also background gamma radiation which may well be abnormally high under emergency conditions.

With the gamma compensation facility switched out, the instrument can be used additionally for general scanning, detecting both beta and gamma radiations. Under these conditions the alarm level will be three times that for beta radiation only.—*Plessey Nucleonics Ltd., Weedon Road, Northampton.*

For further information circle 17 on Service Card

18. Electronic Control Meter

LELAND LEROUX announce a new electronic control meter by International Instruments Inc., of Connecticut, U.S.A., operating without electrical contacts and providing the multiple advantages of continuous output signal past the control setting, with accuracy, uninterrupted full-scale indication and automatic resetting.

Contactless operation, with no electrical contacts at the control point eliminates contact resistance, flutter and corrosion. It also permits accurate full-scale indication at all times, above and below set point, and renders unnecessary such additional items as special power supplies, reset mechanisms, pull-in and locking coils, and its completely isolated indicating and transistorized switching circuit eliminates undesirable feedback.

The heart of the electronic control meter is a meter movement and two coils—one oscillator coil and one pick-up coil, both in the vertical plane. The position of these coils is adjustable by means of a movable control arm, and they may be set to correspond with any point on the scale.

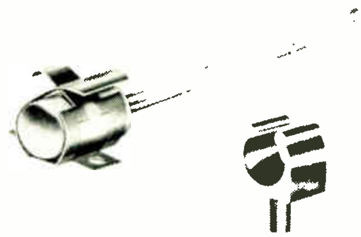
In operation, a vane attached to the rear extension of the pointer of the meter movement passes between the coils; disturbance of the oscillation between these coils by the interposition of the vane creates a signal, which is amplified by the transistorized section. This signal remains 'on' so long as the pointer is beyond the selected point because the coils continue to be shielded while the pointer is beyond the set point. This gives continuous output signal at and above a selected control setting. The pointer may travel further upscale to continue to give accurate readout at all times. When the input signal to the meter movement drops below the control setting the control signal immediately goes 'off' as the coils are then no longer shielded by the movable vane. This gives automatic resetting as the control system goes 'off' or 'on' depending on the direction of the pointer travel.

The new electronic control meter is known as the Model 2547, and is available in two standard types, respectively incorporating one, or two, independent control-arm circuits; and it is available with scales for horizontal or vertical mounting. These instruments are available with zero at left, right or centre according to circuit and installation design requirements.

All models are designed for operation with a power input of 22½ V d.c. at 10 mA for the switching circuit. Meter movements are available in a wide variety of a.c. and d.c. ranges.—*Leland Leroux Ltd., 145 Grosvenor Road, Westminster, London, S.W.1.*

For further information circle 18 on Service Card

EQUIPMENT review



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19. Transistor Clips

AVAILABLE from Plessey are two transistor clips Types A and B, which are intended for 5 or 6-mm nominal diameter transistors.

The Type A clip is moulded in virgin polythene which incorporates a high density pigment to eliminate absorption of ultraviolet radiation. This pigment also serves to identify the two sizes of clip—black for 5-mm and brown for 6-mm diameter transistors. The polythene used is completely inert and will not affect protective coatings on either metal or glass-cased components. Tests indicate that these clips do not limit transistor heat dissipation and can be used over a range of ambient temperatures from −55 °C to + 70 °C.

The mounting of this type is designed for single shank fixing for high speed assembly into printed-circuit boards.

Type B is formed from beryllium copper, hardened by heat treatment. One clip covers both 5 and 6-mm diameter transistor units.

Two holes are provided to enable the clip to be riveted to the board or chassis. The spacing from the clip edge to the transistor lead soldering points should be arranged to accommodate the minimum lead lengths recommended by the transistor manufacturers. After springing open, the transistor is inserted, and the clip released to grip the unit.

Transistors can be operated at full power rating.—*The Plessey Co. Ltd., Ilford, Essex.*

For further information circle 19 on Service Card

20

21

20. Direct Angular Measurement Device

THE THETA INSTRUMENT Corp. of U.S.A. announce the availability of their 'Decitrak' direct-decimal shaft-position encoders, offering the convenience of a true decimal output without a translation circuit.

The uniquely simple two-element design of the 'Decitrak' encoder eliminates many weaknesses inherent in conventional brush-commutator encoders. The transmitter performs the conversion from shaft position to true 10-wire digit code directly; no flip-flops or other 'translation' devices are required. The only associated electronics is an array of simple, solid-state gate circuits, completely uncritical as to power supply, ambient temperature, component aging or signal 'purity'. With this gate logic, 'Decitrak' eliminates all forms of readout ambiguity (it cannot generate false readings, even at cardinal point transitions), and it will function without error five to ten times longer than conventional encoders. Accuracy (and resolution) is 1 part in 4,000 (±0·025%) in a single speed system. By combining two transmitters in a multi-speed (geared) system, almost unlimited accuracy and resolution may be obtained. (In a typical two-speed extension of the system, resolution and accuracy of 6 seconds of arc are achieved: 359° 59·9′ full scale.)

'Decitrak' will drive any commercial 4-digit readout and is compatible with any digital printer. With a continuous output and essentially instantaneous response, 'Decitrak' is claimed to offer significant advantages in replacing servo-repeaters.

The 'Decitrak' transmitter is housed in a standard No. 25 servo case and weighs only 11 oz. A typical power supply requirement is 28 V d.c. unregulated. The gate array is approx. 4 in. × 6 in. × 4 in., and weighs approximately 15 oz.—*Theta Instrument Corporation, 520 Victor Street, Saddle Brook, New Jersey, U.S.A.*

For further information circle 20 on Service Card

21. End-Window Photomultiplier

A PHOTOMULTIPLIER TUBE, with an improved response speed, for scintillation counters and other low-light applications has been introduced by A.E.I.

The tube, the Ediswan 27M14, is a ten-stage end-window photomultiplier of a circularly-focused structure which gives a high response speed (e.g., a rise time of 3 millimicroseconds at an anode potential of 1,000 V), a very short transit time, and higher linear output pulse currents than the more conventional venetian blind structure.

The overall length is 147 mm, the base diameter is 58·7 mm, and the cathode diameter is 42·7 mm.—*Associated Electrical Industries Ltd., Telecommunications Division, Radio Components Dept., 155 Charing Cross Road, London, W.C.2.*

For further information circle 21 on Service Card

22. Complete Vacuum Systems

NOW AVAILABLE from Mullard is a complete vapour-free vacuum pumping system for operation down to pressures of 10^{-10} torr, and ready for operation within minutes of delivery.

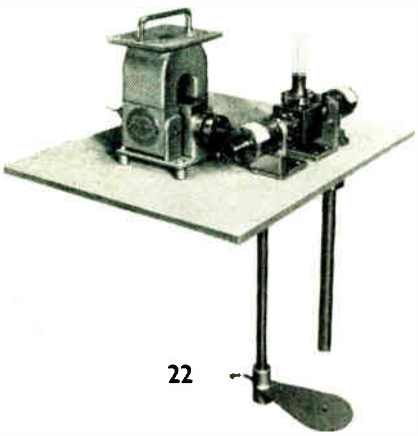
The system (type number UHPS-1) uses one Penning pump, two vacuum taps and one sorption pump all mounted on a heat resistant bench top. Leak rate is tested before delivery to ensure that it is less than 10^{-8} lusec. (One lusec corresponds to a leakage rate of 10^{-3} torr per second in a volume of one litre.)

Because the UHPS-1 will pump down to pressures of the order of 10^{-10} torr in only a few hours it is expected that in the near future it will replace, in many instances, the conventional diffusion and rotary pump equipments which take several days to reach such low pressures.

The sorption pump (Mullard type VAP-10) will pump down volumes of up to 5 litres to a pressure of 10^{-3} torr, the starting pressure of the Penning pump (Mullard type VPP-5). Pump-down time will depend on a number of local factors such as water vapour content and internal impedance, but typically pump-down should be completed in less than 15 minutes. The VAP-10 is of stainless steel construction and is, therefore, corrosion proof.

Pumping action is continued from 10^{-3} torr to 10^{-10} torr by the VPP-5. Over this range the pumping speed for air is 5 litres per second. The VPP-5 is contained in a stainless steel case with a metal lead-in consisting of a vacuum-tight insulating seal. The pump is connected to the vacuum system by means of a flange and a demountable metal seal. Power requirements are: open-circuit voltage 3·0 kV; maximum load current 200 mA. A suitable unit which incorporates a meter calibrated directly in torr is available.—*Mullard Ltd., Mullard House, Torrington Place, London, W.C.1.*

For further information circle 22 on Service Card



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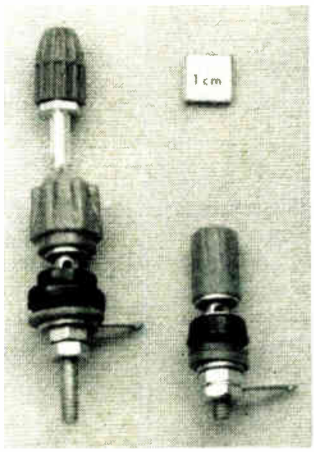

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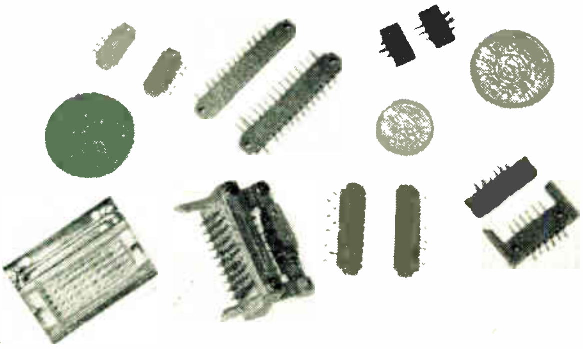
23. Instrument Terminal

AN INTERESTING terminal for instrumentation was announced recently by Belling & Lee. This is a smaller version of their 'Continental' range, but has the same current rating of 15 A. It incorporates a new mounting collar and bush assembly, which fits an area only 12·7 mm (0·5 in.) square at the rear of the panel to facilitate corner mounting, but may also be used with the standard 'B', 'L', and 'W' type fittings if desired.

The new terminal, L.1568, is suitable for metal or insulated panels from 1·2 to 3·2 mm (0·046 in. to 0·125 in.) thick. Like the larger version, its head is moulded in polypropylene or nylon, and there is the same choice of six standard colours, black, blue, green, red, yellow, and natural white. A top socket is provided for 4 mm wander plugs. The clamping gap is free from threads, and has a 2·4 mm (0·093 in.) diameter crosshole for tag pins.—*Belling & Lee Ltd., Great Cambridge Road, Enfield, Middlesex.*

For further information circle 23 on Service Card

24



24. Microminiature Multiway Connectors

BRITISH CENTRAL ELECTRICAL are now marketing a range of microminiature multiway plug and socket connectors. These are available in 3, 5, 6, 10 and 15-way plug and socket strips with 0·1-in. pin spacing, mounted in 3-mm thick Rilsan insulating strip (Rilsan is a nylon type material). The rating of each pin is 3 A at 240 V a.c. or d.c.

The contacts are of the floating, self-aligning type and are gold plated. The connectors can be used singly or joined together in multilayer stacks to make multiway plugs and sockets from 3 to 340 pins or more.—*British Central Electrical Co. Ltd., 6 & 8 Rosebery Avenue, London, E.C.1.*

For further information circle 24 on Service Card

25. Sweep Generator

A SWEEP GENERATOR developed by Telonic Industries Inc. especially for laboratory and production testing of u.h.f. television equipment is now available through Livingston Laboratories. This instrument, designated SD-3M, has a centre frequency range tunable from 440 to 920 Mc/s, with

EQUIPMENT

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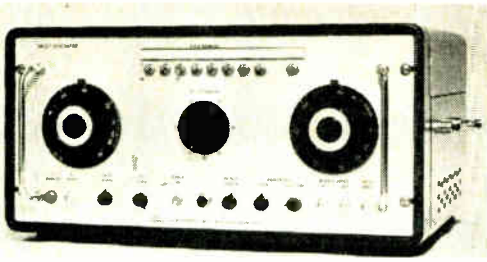

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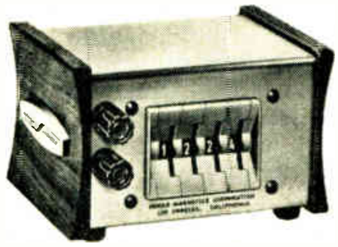

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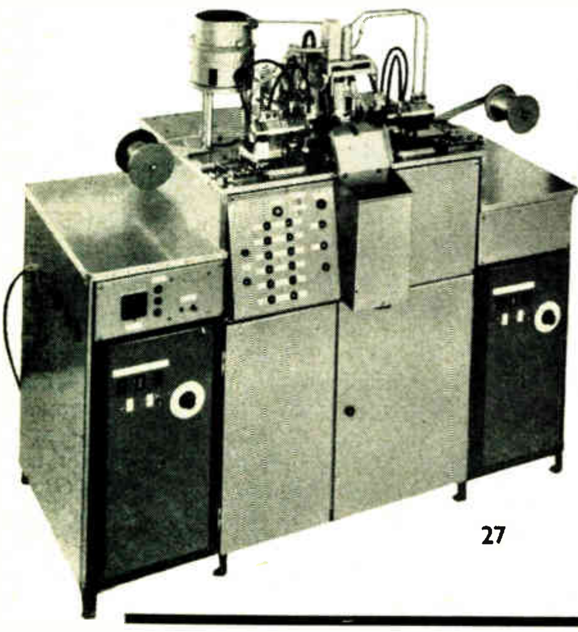

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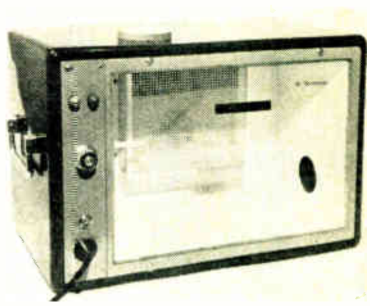

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sweep widths adjustable from 0·06 to 10% of cycle frequency. The sweep rate is 50 c/s.

The generator provides a maximum r.f. output of 0·75 V r.m.s. into 50 Ω and an oscilloscope sweep output of approximately 20 V peak to peak.

A feature of the SD-3M is a built-in variable marker operating as a frequency reference over the range 400 to 920 Mc/s with an accuracy of 0·25%. In addition, sockets are provided for up to eight plug-in crystal markers, which can be selected by separate switches mounted on the front panel.

The SD-3M is available in cabinet form or with a dust cover for 19-in. rack-mounting.—*Livingston Laboratories Ltd., 31 Camden Road, London, N.W.1.*

For further information circle 25 on Service Card

26. Compact Decade Capacitor

A COMPACT decade capacitor which features direct digital readout is announced by Arnold Magnetics Corporation of the U.S.A.

Designated Model CDB, the unit is another in the Arnold 'Digibox' line of laboratory-grade instruments providing direct digital presentation of component values. Operating range is 0 to 0·9999 μF in steps of 100 pF. The accuracy is ±1%, frequency range 30 c/s to 200 kc/s.

The size is 4 in. × 5 in. × 3 in. high and delivery can be made from stock. —*Sylvan Ginsbury Ltd., 8 West 40th Street, New York 18, New York, U.S.A.*

For further information circle 26 on Service Card

27. Automatic Welding Machine

FOR THE automatic welding of wire, supplied from a continuous coil, to capacitors, resistors and similar cylindrical components, Witte & Sutor of Western Germany are marketing a fully automatic welding machine.

The machine is designed so that the cylindrical components are placed in a vibrating hopper and from there the components are automatically fed by a conveyor channel to a magazine which transfers each component to the welding head. Wires are then fed simultaneously from two directions, cut to the required length and butt welded to each end face of the component; they are then ejected.

The output of this machine is approximately 1,500 double welded components per hr.

The basic model can handle components from approximately 8 to 60 mm in length and 2 to 15 mm in diameter.—*Witte & Sutor GMBH, 7157 Murrhardt/Württ, Western Germany.*

For further information circle 27 on Service Card

28. Air Thermostat

WAYNE KERR have produced a portable air thermostat, Type AT205, whose internal temperature is electronically controlled, with a stability of better than 0·05 °C over 24 hours. The capacity is approximately 3 to 4 cu ft and a front panel control enables the temperature to be set anywhere within the range 20 to 30 °C or, on an alternative model, from 30 to 40 °C. The inner enclosure is insulated from the steel case and the electronic circuits are housed in a separate compartment at one side of the case. Bungs are provided to permit the insertion of a thermometer and manipulation of the enclosed specimen which is completely visible through the transparent front panel.

The Air Thermostat is particularly suitable for experiments relating to the temperature coefficients of electrical components such as wire-wound resistors or ceramic capacitors, the performance of crystals cut for low-temperature operation, and incubation measurements on biological tissues. A further important application is for permittivity and conductivity measurements at controlled temperatures.

Operation is based on a thermistor associated with a transistorized control circuit suitable for 110 or 200-250 V supplies, consuming less than 30 W. The technique developed overcomes the disadvantages associated with the mercury-toluene type of regulator. Accurate temperature stability is achieved rapidly and fully maintained even when the ambient temperature rises to within 2 °C of the enclosure. The enclosed air is constantly circulated over the heating elements, ensuring an even temperature throughout all parts of the enclosure.—*Wayne Kerr Laboratories Ltd., New Malden, Surrey.*

For further information circle 28 on Service Card

29. Counter-Tachometer

THE COUNTER-TACHOMETER type M.1157 is a transistorized digital frequency and time interval meter which is produced by Southern Instruments. It is especially useful in tachometry applications to indicate speed directly in r.p.m. Its principle features are the fully variable digital time base, a high input impedance, and the easy to read in-line in-plane display.

Count periods between 1 millisecond and 10 seconds in millisecond steps are available for the measurement of frequencies from 0·1 c/s to 120 kc/s: the counting interval may also be controlled manually or externally, by signals and/or contact closures, for the general determination of the number of events per unit time. Time intervals defined by electrical signals and/or contact closures are measured in clock units of 0·1, 1 and 10 milliseconds, 0·1, 1 and 10 seconds to a maximum of 10,000 units. The clock pulses are internally generated from a quartz crystal source and are available at outlets on the front panel for time calibration applications.—*Southern Instruments Ltd., Frimley Road, Camberley, Surrey.*

For further information circle 29 on Service Card

29

30. 'Ovalgrip' Cable Markers

A RANGE of sleeves and cable markers that have been designed for fitting without the aid of tools is now available from Hellermann.

'Ovalgrip' are oval in design and are fitted simply by being pressed into a circular shape with finger and thumb and placed over the cable or terminal and then released.

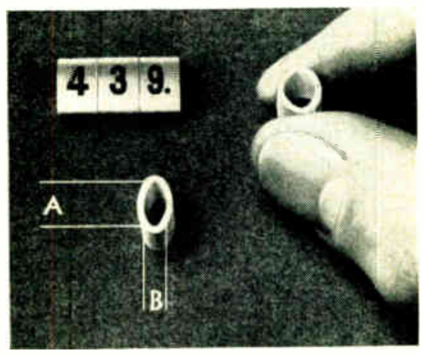
The 'Ovalgrip' sleeve will then revert back to its original oval shape tightly gripping the cable.

A range of ten colours is immediately available (registered colour-code as specified in DEF 20A) for either plain sleeves or markers. 'Ovalgrip' with customers' special markings can be supplied upon demand.

Manufactured in p.v.c., 'Ovalgrip' ranges in size from (Int.Dia. 'A') 0·050 in. up to 0·338 in. and (Int.Dia. 'B') 0·015 in. up to 0·098 in.

The 'Ovalgrip' series can be supplied to fit maximum outside diameters of cables from 0·035 in. up to 0·235 in. —*Hellermann Ltd., Gatwick Road, Crawley, Sussex.*

For further information circle 30 on Service Card



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31. Process-Control Level Switches

MAGNETIC INSTRUMENTS 'Procetrol' level switches for process control applications are designed to detect and either indicate and/or control the level of liquids and granular/powdered solids, according to predetermined level set-points. Each 'Procetrol' level switch is composed of a level-sensing probe, and an indicating/relay-actuating control unit. The output of the switch is normally a s.p.d.t. relay, but other output modes may be obtained. These switches find wide use because of their sensitivity, simplicity, and ruggedness at a comparatively low cost.

The control unit models include the simplest integral head for use where process tank temperature does not exceed 120 °F, to remote-control units, with fixed or adjustable set-points. All control units are solid-state in design and operate at temperatures from 0 to 120 °F.

The probes vary from the most-widely-used Dupont Teflon-coated model to the highly sensitive model for electrically non-conductive/low-dielectric-constant fluids. Probes operate at a temperature of max. 475 °F continuous, standard 300 p.s.i.

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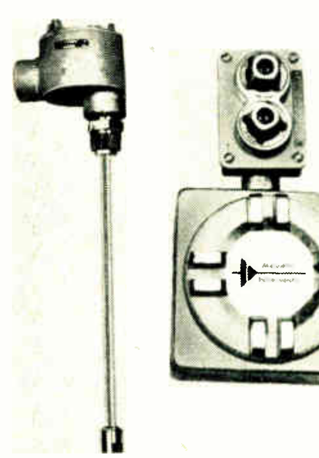

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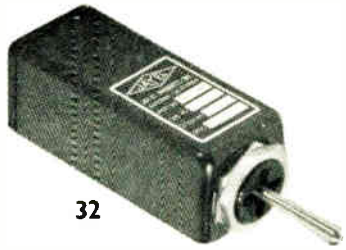

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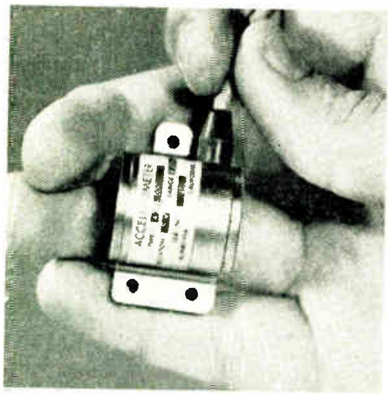

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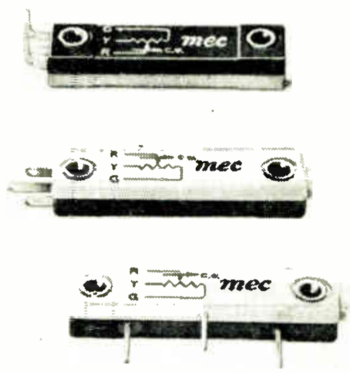

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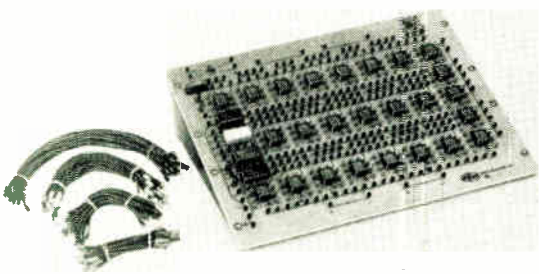

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operating pressure. Special configurations are available.—*Ad. Auriema Ltd., 414 Chiswick High Road, London, W.4.*

For further information circle 31 on Service Card

32. Plotter Switch

A FOUR DIRECTION toggle control switch is being produced by Jay-El Products, Inc., U.S.A. This panel control features a positive tactile switching action in each quadrant, with a spring return to a neutral centre. Contact rating is 10 A inductive at 30 V d.c. with the mechanical life of each switch rated above 20 million cycles. It is ideally suited as a central control of four separate functions. The switch contact assembly is removable while the toggle unit is mounted.

A splash-proof version of the Plotter Switch is also available. This unit mounts inside a $1\frac{1}{8}$ in. square area with the extension back of the panel held to $3\frac{1}{4}$ in.—*Jay-El Products, Inc., 1845 West 169th Street, Gardena, California, U.S.A.*

For further information circle 32 on Service Card

33. Strain-Gauge Accelerometer

A STRAIN-GAUGE accelerometer which is designed to measure accelerations parallel to the mounting surface is now being marketed in the U.K. by Consolidated Electrodynamics.

Known as the type 4-203, it is claimed to be the smallest temperature-compensated strain-gauge accelerometer commercially available, being 1-in. cube and weighing less than 3 oz. Other features claimed for the unit include small damping change with temperature, low cross-axis response and high resonant frequency.

The type 4-203 is available in eight ranges from ± 5 *g* to ± 500 *g* and the operable temperature range is from 300 °F to −70 °F. The sensitivity perpendicular to the sensitive axis is less than 0·01 *g* per *g*, for inputs of three times the rated range or 150 *g* input, whichever is the smallest. Damping is $0{\cdot}7 \pm 0{\cdot}1$ of the critical at 77 °F. The combined linearity and hysteresis is rated at less than $\pm$ 0·75% of the full-range output. The accelerometer has provision for strain-gauge bridge electrical compensation external to the sealed damping-media-filled chamber. —*Consolidated Electrodynamics (U.K.) Ltd., 14 Commercial Road, Woking, Surrey.*

For further information circle 33 on Service Card

34. Mecpot Potentiometers Up-Rated

THE M.E.C. Mecpot potentiometer range has now been extended and the ratings increased.

Existing models have been joined by the model MP32 and the rating of all Mecpot potentiometers has been increased from 0·75 W to 1 W at 20 °C.

The MP32 has three pins spaced along the length of the body, for direct mounting into printed wiring boards using the 0·1-in. module. These miniature pre-set potentiometers are available with total resistance values from 10 Ω to 20 kΩ and they will operate up to a maximum temperature of 85 °C, with a $\frac{1}{4}$-W dissipation.—*Miniature Electronic Components Ltd., St. Johns, Woking, Surrey.*

For further information circle 34 on Service Card

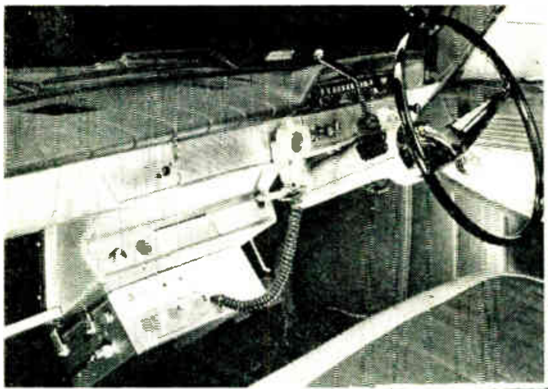
35. Magnetic Logic Breadboard

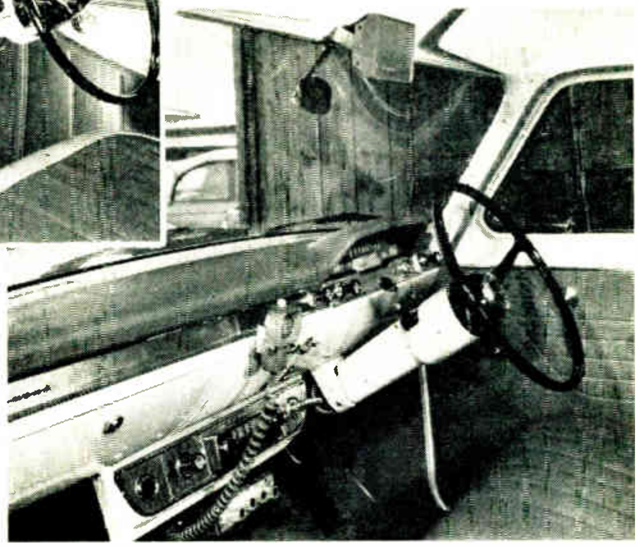
A MAGNETIC logic breadboard has been introduced by DI/AN Controls Inc. for magnetic logic development in the fields of education, design and research.

The breadboard provides for demonstrations of all logic circuits, evaluation of core-logic systems for compatibility with other circuitry, life-test, marginal test, examination of operating margins, signal-to-noise ratios, etc., on practical working elements.

The breadboard has 25 core-transistor logic modules, two core-transistor input amplifiers and one 5-kc/s oscillator permanently mounted and wired to the jacks on the panel.

36





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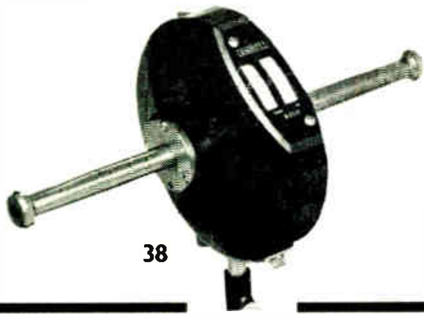

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Provision has also been made for an additional optional circuit module. All permanent connections are made through printed circuits on the back of the panel. Interconnection between the modules is made with the 150 patch cords furnished for this purpose.

Core-transistor modules combine logic, power, storage and signal regeneration in one compact non-critical and reliable building block. The minimum life expectancy is 50,000 hr at full rating at worst rated extremes of temperature (−55 °C to +125 °C) and at 100% humidity. Repetition rates up to 750 kilobits/sec are available.—*Scientific Furnishings Ltd., Poynton, Cheshire.*

For further information circle 35 on Service Card

36. Miniature Soldering Iron

THE LAST few years have seen the rapid development of sub-miniature components and the development of efficient tools to handle these components—not least important of these being the soldering iron. Antex have developed a range of sub-miniature soldering irons to meet the present-day needs and the latest addition to this range is the Model E. This is a 20-W, mains-operated soldering iron that weighs $2\frac{1}{4}$ oz and is designed with replaceable bits of $\frac{3}{32}$ in., $\frac{1}{8}$ in., $\frac{3}{16}$ in. and $\frac{1}{4}$ in. diameter. Three different versions are available for 110 to 120 V, 220 to 230 V and 230 to 250 V operation and chisel-, spade- and angle-shaped bits of various materials are also available. The price of the soldering iron is 35s.—*Antex Ltd., Grosvenor House, Croydon, Surrey.*

For further information circle 36 on Service Card

37. Two-Way Radio

FOR OPERATORS of small vehicle fleets Pye Telecommunications have produced two mobile radiotelephone equipments.

The car-boot-mounted equipment is named the 'Vanguard'. It is a 25 W. v.h.f., a.m. radiotelephone with 4-W audio output. The control unit and a separate speaker are mounted near the driver while the remaining main unit is mounted in the boot.

The other equipment is named the 'Cambridge' and designed for mounting under the dashboard of a car. It is 6-W v.h.f. equipment with a completely transistorized receiver.

Each equipment can be supplied with the facility of single or six-channel operation.

The range of each model will depend on the surrounding terrain, etc., but an average figure for the 'Vanguard' is 25 miles and for the 'Cambridge' 15 miles.

The 'Cambridge' radiotelephone can be rented at about 20s. per week for the mobile units and 30s. a week for the fixed station.—*Pye Telecommunications Ltd., Newmarket Road, Cambridge.*

For further information circle 37 on Service Card

38. Q-Band Attenuator

ELLIOTT BROTHERS announce a Q-Band (W.G.22) Rotary Vane Attenuator type 2218. This attenuator possesses all the important features of the Precision Rotary Vane Attenuator but sells for less than half the cost at £95. This low price for a precision instrument is achieved by simplification of the construction, and replacement of the fine drive and engraved vernier scale by a very simple drive and a photo-printed scale. The instrument is direct reading with the following resolution: from 0 dB to 1 dB, 0·1 dB divisions; from 1 dB to 5 dB, 0·2 dB divisions; from 5 dB to 30 dB, 1·0 dB divisions; from 30 dB to 50 dB, 5 dB divisions. By interpolation it is possible to reset to approximately $\frac{1}{2}$ of a division. A v.s.w.r. scale is also provided. The instrument is available with flange types 5985-99-083-0018 UG 599/U or UG 381/U on short delivery terms.—*Elliott Brothers (London) Ltd., Microwave & Electronic Instruments Division, Elstree Way, Borehamwood, Herts.*

For further information circle 38 on Service Card

THIN-FILM TRANSISTOR

A new type of transistor, which can be manufactured by thin-film deposition techniques, is described. It is at present in the experimental stage, but it could well be an important development in microminiaturization.

NORMALLY a transistor is manufactured from single-crystal semiconductor material, generally germanium but sometimes silicon. There is now news of an entirely different technique whereby a transistor can be made by the deposition on a substrate of thin films of conducting and semiconducting materials. Not only is the construction apparently greatly eased by this process but associated circuit elements, such as resistors and capacitors, and, of course, connectors, can simultaneously be produced. The process is thus one which lends itself admirably to microminiaturization.

So far, thin-film transistors are experimental. Early models had a mutual conductance of 5 mA/V at a current of 6·5 mA. In later ones this was raised to 25 mA/V. No particular care has yet been taken to design units for high-frequency operation, but oscillation has been obtained with existing types up to 17 Mc/s.

The construction and theory of the device is described in the June 1962 issue of *Proc. I.R.E.* ('The TFT—A New Thin-Film Transistor' by Paul K. Weimer, p. 1462). The electrodes are given names different from those of the conventional transistor and different again from those of the thermionic valve. In all cases they are functionally analogous, however, and Table 1 shows the equivalence in the three cases.

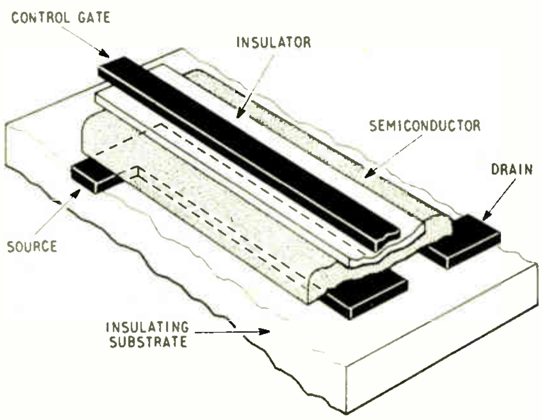

Fig. 1.—Cross-section and plan of thin-film transistor. The thickness of the layers and the electrode spacings are only a few microns

[*Courtesy Proc.I.R.E.*]

TABLE 1
Electrode Equivalence

Valve	Transistor	Thin-Film Transistor
cathode	emitter	source
grid	base	gate
anode	collector	drain

The form of construction is shown in Fig. 1. The insulating substrate is a glass plate upon which the source and drain electrodes are deposited. These are of a metal suitable for making low-resistance contact to the semiconductor. Typically, gold is used and is evaporated on to the substrate with the usual masking arrangements to define the deposited areas; the separation of the electrodes is some 5–50 microns.

A semiconducting layer of cadmium sulphide is then deposited to overlap the source and drain electrodes. This forms a layer of under one micron in thickness. The outer surface is then covered with a thin layer of silicon monoxide to act as an insulator, and on this in turn a gold layer is deposited as the gate electrode.

The characteristics of one experimental transistor are shown in Fig. 2. The device depends on electrons as charge carriers and so the drain requires to be positive with respect to the source. Operation can be with the gate either positive or negative and in neither case is there appreciable gate current. The curves of Fig. 2 are for a positive gate and operation is said to be in the 'enrichment' or 'enhancement' mode. Negative gate voltage is said to produce operation in a 'depletion' mode.

Fig. 3 shows curves covering both modes, and Fig. 4 illustrates the effect of illuminating the device. Cadmium sulphide is a light sensitive material and illuminating the transistor with 20 foot-candles produces a large increase of drain current.

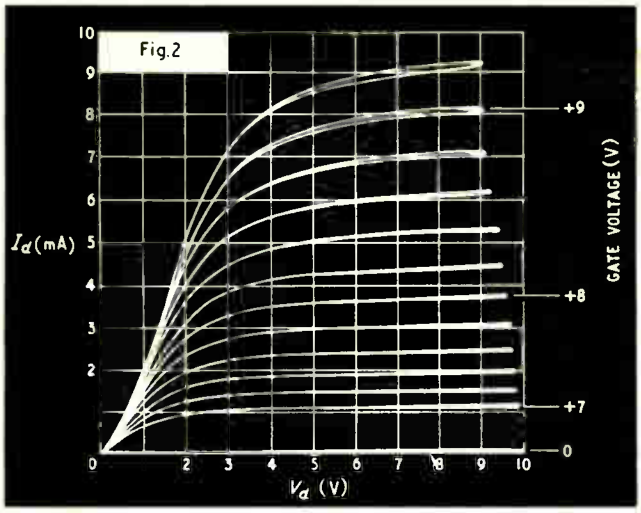

Fig. 2.—Characteristics of a cadmium sulphide transistor operating in the enrichment mode with positive gate
[*Courtesy Proc.I.R.E.*]

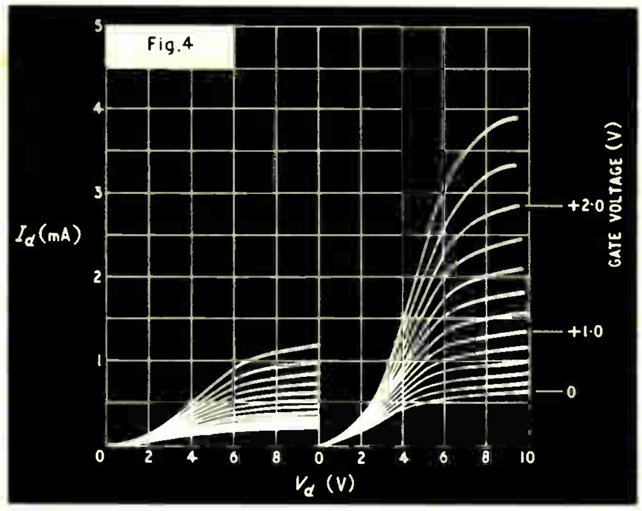

Fig. 4.—The effect of light on a thin-film transistor. The left-hand characteristics are for dark operation, the right-hand when illumination is 20 foot-candles
[*Courtesy Proc.I.R.E.*]

The input capacitance is quite large, 300 pF in early models. However, this has been greatly reduced and types with a capacitance of 50 pF and a mutual conductance of 25 mA/V have been produced. Such types have a gain-bandwidth product of about 12 Mc/s.

With positive gate operation the required gate voltage is of the same order as the drain voltage. Consequently direct coupling of one drain to the next gate in cascaded stages is very easy and lends itself to an economical structure in which a complete amplifier is constructed entirely by the evaporation of thin films.

The theory of the device is not yet fully understood. In particular the reason for the hysteresis loop, which can be seen in the more positive gate-voltage curves in Figs. 2 and 3, is not yet known. However, many if not all of the characteristics can be explained in terms of field-effect considerations.

The thin-film transistor is not yet developed to the production stage. It appears so attractive, however, that it will be surprising if more is not heard of it. Indeed, unless some major 'snag' is encountered it could revolutionize microminiaturization practice.

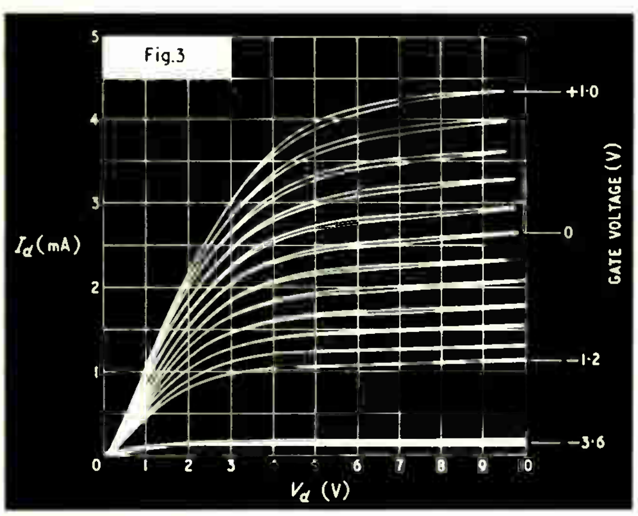

Fig. 3.—Characteristics of a unit operating in either 'enrichment' or 'depletion' modes. Note the hysteresis effect evident at positive gate voltages
[*Courtesy Proc.I.R.E.*]

Cyclotron Wave Phase Shifter

A new and precise method of shifting the phase of u.h.f. and microwave signals was recently demonstrated by Zenith Radio Corporation at the National Electronics Conference in Chicago, U.S.A. An electron beam serves as the signal transmitting medium ; its phase transfer function can be varied by hundreds of degrees at megacycle rates, with a linear relationship between phase shift and externally-applied control current. Insertion loss, which does not change with phase shift, is between 1 and 2 dB. Transmitted r.f. power capability can range from a few microwatts (initial demonstration of this phase shift method was at −20 dBm) to many kilowatts. The phase shifter also functions as an isolator, providing stable matched impedance at its input and output together with about 60 dB of reverse attenuation. Utilizing the cyclotron rotation of free electrons in a beam, the device is free from the hysteresis effects and temperature variations common to ferrite devices and exhibits a high degree of stability.

In the electron beam phase shifter, a beam is projected from a gun through an input coupler, a phase shifting region and an output coupler. The phase change is accomplished by varying the magnetic field in the phase-shifting region by means of an external current source which feeds a small solenoid inside the vacuum envelope. The entire tube is immersed in a longitudinal magnetic field. To conserve d.c. power, the collector may be held at a low potential.

After definitions of the more important terms used, and a discussion of points arising from these definitions, descriptions are given of some practical learning and memory machines. Possible parallels between the performance of machines and that of the nervous system are then discussed, and a tentative theory is advanced to account for the operation of the nervous system in a particular learning task.

MEMORY AND LEARNING CIRCUITS

By B. R. WILKINS, B.Sc.(Eng.)*

CONTROL-SYSTEM engineers, concerned with replacing men with machines, often come up against the problem that some particular operation has to be performed by humans because of the difficulty of specifying precisely what the operation is. For example, a letter-sorting system has to include a human to read the address because it is quite impossible to specify mathematically all the different variety of shapes which any given character can assume, and so, it might appear, a machine to perform this operation can never be constructed. Fortunately, however, the outlook is not as black as this. A young child is also unable to sort letters, but after a prolonged training period, during which he receives instruction in the correspondence between shapes and characters, he then has the necessary ability. The change from being useless to being useful in this task is possible because the child possesses the faculties of learning and memory. Clearly, if a device can be constructed which also possesses these faculties, then the control problem disappears: we have only to teach the machine, using a human instructor and a wide variety of character shapes, and we have then obtained the necessary machine without in fact having to define its function mathematically at all.

Reading is only one of many tasks that can come into the sphere of machine operation with the aid of learning circuits, so that it is not surprising that these circuits have been attracting progressively more attention and research effort in the last few years.

Definition of a Learning Circuit

A learning circuit, just like any other circuit, can be regarded as being a closed box with a number of input and output terminals. The features of a learning circuit which distinguish it from any other circuit may be summarized in the following, which will be taken as the definition in the subsequent discussion:

The outputs from a learning circuit in response to any given set of inputs are initially zero or random, but become progressively adapted in some manner under the influence of the accumulated history of inputs to the circuit.

From this definition several points of interest arise.

In the first place, the use of terms like 'circuit', 'terminal', 'inputs and outputs' must not be taken to imply that only artificial mechanisms are included in the discussion. Animals in general and humans in particular are difficult subjects for experiment: individual variations in learning ability are very marked and it is always difficult and often impossible to control the initial conditions in a learning experiment, because of the inevitable variations in the range of individual experience. For these and other reasons it is convenient to experiment and to try out theories with man-made models. Even although such models may have valuable engineering applications in their own right, however, much of the interest in them is aroused by the possibility that by considering parallels between these models and neurological systems, some light may be thrown on the workings of the brain. For any definition of a learning circuit to be generally useful, therefore, it must embrace both artificial and living systems, the distinguishing criteria being dependent on behaviour and not on structure. The definition proposed will apply to any system, provided we are prepared to allow the term 'circuit' to cover, for example, a group of nerve cells, or a complete living organism.

A second point arising from the definition is the meaning of the term 'initially'. This will be taken to be relative to the learning task under consideration in which the learning circuit is involved. In other words, this is the state of the learning circuit when there is no learning in it. The circuit is in this state early in its life before any learning has taken place, which is why the term 'initially' was used, but it can also re-enter the 'initial' state after it has been involved in learning if the learning is forgotten. Many, although not all, learning circuits encountered in practice do forget, so that this return to the initial state is an important feature of learning.

A third feature of the definition which perhaps calls for some explanation is the reference to progressive adaptation of the behaviour of the circuit. This property is really fundamental to the nature of a learning circuit. Without it, we would be obliged to include under the heading of learning circuits a ferrite core in the store of a digital computer. This, like any other form of memory device, could certainly form part of a learning circuit, but cannot by itself constitute

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one. We must therefore note that learning and memory circuits are different, and that the essential distinguishing feature of a learning circuit is its adaptive behaviour, which is the property of modifying its own characteristics in the light of experience. Moreover this adaptation is progressive: that is to say, the behaviour cannot be radically modified without a substantial history of inputs consistently tending to produce similar adaptation. We can see the importance of this point by thinking for a moment of conditioned reflexes. Life would plainly become intolerable if every time that there was a single chance juxtaposition of two unrelated stimuli a conditioned reflex were to be established. To be useful, a reflex must not be set up until the number of such juxtapositions has risen significantly above what might be expected by chance, and this is in fact what seems to happen in nature. This feature of progressive rather than sharp changes is also unlike a normal computer memory element, which simply stores the information which is presented to it.

In the definition, references are made to inputs and outputs. The concept of the circuit possessing input and output terminals is a useful one, particularly in diagrammatic representations, but it must not be taken to imply even in a model that all such inputs and outputs are electrical or even that they are all of the same nature. In fact, both in models and in man, signals of several different kinds are commonly employed (for example, electrical, mechanical, optical and chemical) and these different kinds of signal can occur in the same circuit, so that an optical input may control a mechanical output, or an electrical input may control a chemical output. This leads us to the last point arising from the learning circuit definition: the distinction between control and information pathways. The reference to inputs and outputs in the plural was not intended simply to cover the case in which a single input and a single output are brought out each to a number of terminals, as, for example, is commonly done with d.c. amplifiers in analogue computers (see Fig. 1). This is merely a matter of mechanical convenience: functionally the amplifier has one input and one output. It is possible, however, to have several inputs which are functionally distinct and may be of different physical forms, but whatever their physical forms, all the inputs and outputs can be classified as belonging to either information or control pathways.

Fig. 2, for example, shows an arrangement of a box with a shutter which can be raised from its normal position by energizing a solenoid. When the shutter is allowed to fall back to its normal position no light can pass. Thus, the light signal input, carrying information, can reach the output only when there is a suitable electrical signal at the control input terminal. This kind of action is typical of, although not exclusive to, learning circuits, where an output may be connected to one input either directly or through an amplification or attenuating network, but where the form of the amplification or attenuation or the existence of the connection may be decided by some other quite independent input.

Fig. 3 shows a system precisely analogous to that of Fig. 2, only with electrical information pathways instead of optical ones. If either of the 'boxes' shown in Figs. 2 or 3 were to form part of a learning circuit, it would appear as in Fig. 4, stressing again that in a general consideration of learning circuits we are concerned with behaviour and not with structure.

Types of Learning Process

We must now turn our attention to the learning processes that we wish to be carried out by learning circuits. There are many different kinds of learning process, but for

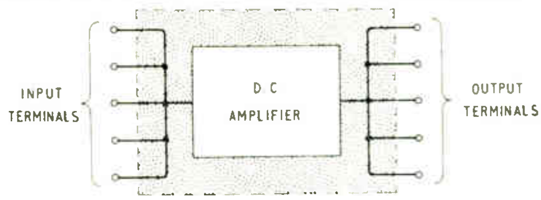

Fig. 1. Computer amplifier arrangement

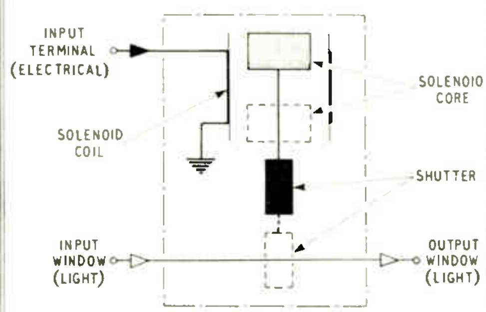

Fig. 2. Simple electro-optical mechanism

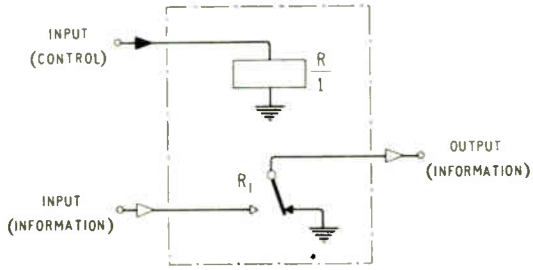

Fig. 3. Electrical analogue of Fig. 2

discussion purposes they will be arranged under four headings.

1. *Association:* This is the simplest possible form of learning, consisting of an association between two independent stimuli, requiring essentially a single binary decision element. A natural example of association learning is the classical Pavlovian conditioned reflex.
2. *Classification:* This is the process of sorting sets of inputs into separate categories in accordance with instructions received during a training period, resulting in a subsequent ability to sort patterns, often even incomplete or defective ones, into the appropriate categories without further need of instruction. A natural example of classification learning is reading.
3. *Position:* This can be regarded as an association learning in which the association is not universal but applies only at some specific point or points of a sensory field. An example of this is the ability to avoid obstacles when crossing a darkened room, using information about the positions of obstacles obtained on some previous occasion.
4. *Co-ordination:* This is the process of learning a continuous quantitative relationship between two different sensory fields so that after a training period any particular point in one field can be related to a corresponding point in the other. An example is the learning of relationships between positions in the visual field and the corresponding placing of the hand required to touch the positions: in other words the co-ordination between hand and eye.

Memory Elements

When discussing the definition of a learning circuit, some stress was laid on the fact that a memory element could not by itself form a learning circuit. Nevertheless, since by definition the characteristics of a learning circuit depend on a previous history of inputs, it must contain some information about this previous history, so that a learning circuit must always contain at least one memory element. Moreover the particular form of the memory element or elements will generally be of fundamental importance in determining the kind of learning of which the circuit is capable.

Before saying any more about learning systems in general, therefore, we must say a few words on the subject of memory. This term has already been used several times, relying on an intuitive understanding of its meaning, but it is perhaps advisable to define it before going further. The following is proposed as a definition:

A memory element accepts and stores in a coded form information about some aspect of an existing situation, releasing this information at some later time in response to control signals.

Memory elements can be classified as qualitative, quantitative or transfer. A qualitative memory element stores information about events or general properties of the environment. This kind of element is used in association and classification learning circuits. A quantitative memory element stores information about properties of specific points of the environment and is the kind of element which forms the basis of a position learning circuit. A transfer element stores information about associations between specific points in different sensory fields, forming the basis of co-ordination learning circuits.

Memory elements of each of these functional classifications can be further classified temporally as either temporary or permanent. This division is of course often rather arbitrary, and with animals or with man it is not easy to know where to draw the line. With machines, however, we can be precise. A memory element will be regarded as permanent only if information placed in it will remain unaltered for an indefinite period in the absence of any further inputs. In models this almost invariably means that it must be a mechanical device (although probably electrically operated). For example, information may be stored as the position of a potentiometer wiper or of a uniselector arm, and in either case the information will not decay. Note, though, that calling a memory element permanent does not mean that the information it contains cannot be changed, but only that it will not change by itself.

The commonest form of temporary memory element is a capacitor on which charge is stored. This charge inevitably leaks away, and although a good capacitor may retain an effective amount of charge for a considerable period, any such element will be classified as temporary.

Features of Memory

At this point it is convenient to introduce a slight extension of terminology. There is some danger of confusion in the use of the term 'memory' as to whether we refer to the information which is stored or to the physical device which stores it. This difficulty has been pointed out by Young[1], who resolves it by calling the device a 'memory', and the information a 'representation'. I find it convenient, however, to adopt a different convention, and to speak of the information as a *memory*, and of the physical storage device as a *memory element*. The complete 'black box' containing one or more memory elements and the associated control circuits is then spoken of as a *memory unit*.

Features of a memory unit which are of interest are the conditions under which a memory can be stored or recalled and also the capacity of the unit. These features are not in general independent. A most important characteristic of any unit is what happens when the unit is full and a new memory is presented. There are two main possibilities: the new memory could be rejected, or an existing memory could be destroyed and the new one stored in its place. These alternatives represent different storage policies, and there is no very clear evidence from experiments with animals or humans to suggest that either policy is definitely to be preferred. On the one hand it seems likely that the latest memory presented will be available in the memory unit rather than older memories, but on the other hand it seems improbable that, for example, a new association should immediately destroy an old and well-established one. Averbach and Corriell[2] have found evidence of destruction of memory in a particular set of circumstances, although in their experiments it is brought about by conflicting information about the same event, rather than by overloading of the memory unit. I have conducted some experiments myself with human subjects, and although in themselves they have been inconclusive, there is some indication that a new memory is sometimes rejected rather than an old one. Further experiments should yield more definite results but for the time being we can say only that neither policy is unreasonable and that evidence to support one to the exclusion of the other is lacking.

The question of saturation of the memory unit is bound up with an important property of the memory itself. We must observe that neither storage nor recall is a straightforward operation as it is, for example, in a digital computer, where once a decision has been made to store or recall from a particular element the appropriate control lines are energized and the storage or recall takes place. In a learning circuit storage and recall are dependent not only on the control signals but also on the memory in the element. In an association circuit, for example, it was pointed out earlier that a single juxtaposition of two separate stimuli must not establish a conditioned reflex. However the fact that this juxtaposition has occurred must be

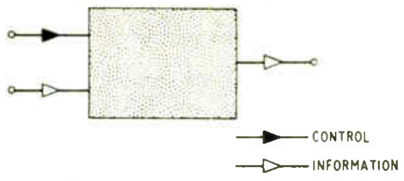

Fig. 4. Symbolic Representation of Figs. 2 & 3

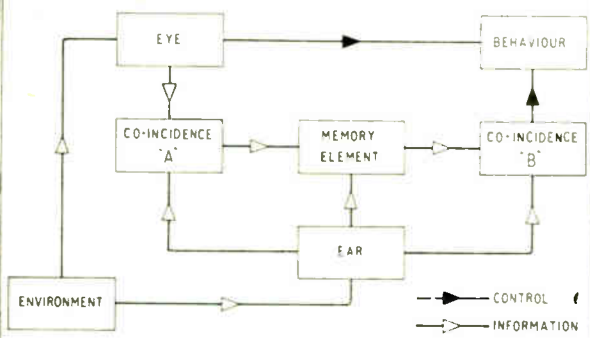

Fig. 5. Block diagram of Huggins's 'dog'

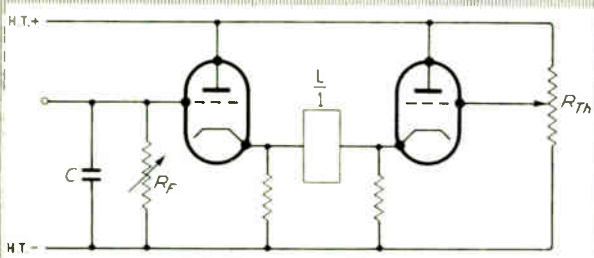

Fig. 6. Memory element

memory and learning circuits

recorded: it might be the first of a long series, and in this case an association should eventually be established. The element, therefore, is occupied, so that storage of new information in that element is prevented, but at the same time the memory cannot be recalled so as to affect behaviour. With repetitions of the juxtaposition of stimuli, the reflex is eventually established, but without continued repetitions extinction of the reflex occurs and ultimately the memory may be lost altogether and the element becomes available for storage of other information. Throughout these changes, however, the nature of the memory remains unchanged. The differences may be ascribed to a property which will be referred to as *strength of memory*. Wells and Wells[3] have deduced the existence of this property in the octopus. They trained octopuses to perform tactile discriminations and then allowed an interval of some days. When retested, the animals reacted uncertainly, but the amount of retraining necessary to get them back to their former performance figures was significantly less than the amount of training required originally. This demonstrates that the memory itself was still present, although the power to recall it had diminished. Wells and Wells also suggested, on the basis of their results, that recall could become impossible due to a low strength of memory.

It is here suggested that strength of memory is a fundamental concept in learning circuits. It is suggested that the strength of memory component is incrementally increased with the input of information to the element, and otherwise decays continuously towards zero. For the purposes of subsequent discussion, three threshold values will also be defined, although not all of them are necessarily present in every element. The *first threshold* determines whether the element is regarded as occupied or empty by the storage mechanism when it is seeking a location for a new memory. The *second threshold* determines whether the recall mechanism is able to extract the memory. The *third threshold*, which will be discussed later, determines whether a temporary memory becomes permanent. Thus the property of strength of memory is seen as holding a central position in the mechanism of learning, exercising an over-riding control over the functioning of the memory unit.

For completeness, we should mention here one more feature of memory: accuracy. This concerns only position and co-ordination systems, and is a measure of how closely the information extracted from the memory element compares with the information put in. We would like the comparison to be exact, but in practice it cannot be, and we then have to ask what accuracy is necessary to enable the learning circuit to do what is required of it. To help to decide this, we can examine evidence of man's ability in comparable situations. We will pursue this a little further when we discuss neurological parallels.

Simple Learning Circuit

We will turn now to an examination of a particular learning circuit of a very simple kind. Despite its simplicity however, it does bring out a number of interesting points. The circuit, described by Huggins[4], was designed to exhibit the characteristics of Pavlov's dog by learning to associate the sound of a bell with the appearance of food. It is an association learning circuit, whose memory unit contains a single temporary qualitative memory element.

Fig. 5 shows a block diagram of the circuit. The box marked 'behaviour' represents the mechanism of salivation, whose activation is indicated in this model by the lighting of a pair of lamps. This activation can be produced by a control signal either from the eye or from the coincidence 'B' unit. Activation by the eye represents the normal response of an untrained animal to a signal from the environment indicating the appearance of food.

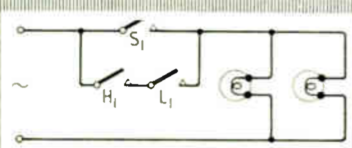

Fig. 7. Control of behaviour

The coincidence 'B' unit can activate behaviour only when it is simultaneously stimulated by the memory element and by a signal from the environment through the ear. The memory contained in the memory element is a quantity which increases with simultaneous activations of eye and ear, detected by the coincidence 'A' unit, and decreases with activations of ear alone.

The circuit diagram of the memory element is shown in Fig. 6. Positive charge is added to the capacitor C when the coincidence 'A' unit is activated, and removed from it when the ear is activated. There is also a continual leakage of charge through the resistor R_F which governs the rate of forgetting. R_{th} sets the threshold level (in terms of the earlier nomenclature this is a second threshold) and so determines how much charge has to be stored in C to energize relay L.

Fig. 7 shows how 'behaviour' (the lighting of the lamps) is brought about. The S and H relays are energized by the eye and ear respectively.

It is interesting to observe that in this circuit the memory consists solely of a strength of memory component, the qualitative information in the memory being inherent in the wiring. In other words, this memory element is a special purpose one, able to store information only about particular events (seeing and hearing) specified by the structure of the mechanism. For this reason there is no first threshold: information about these particular events is always stored in this element, so the problem of finding a vacant element is eliminated. Thus the control circuitry is made very much simpler than in the general case, but the resulting machine is a special purpose one, able to form only those associations which were envisaged by the maker. To make a machine on these lines general would mean supplying a memory element for every possible association, so that the simplicity of control is then paid for by the complication of having a very large number of memory elements. A machine working on this principle has in fact been made by Uttley[5].

(To be concluded)

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ENVIRONMENTAL MOTION SIMULATOR

A 2-axis rocking table which has been designed by Short Brothers & Harland for use in testing their Belfast freighter's Autoland system, has proved so successful that the Company is to build a general purpose, production version. The new design is suitable for the testing of all kinds of gyroscopic equipment.

The 'Belfast' rocking table carries those units of the automatic landing system which sense the aircraft's attitude in pitch and roll. By tilting these units to the correct angles, in response to electrical signals from an analogue computer, the rocking table causes them to function exactly as they would during an actual flight. It is powered by electro-hydraulic servomotors operating at 2,500 p.s.i. The analogue computer can be programmed to provide, for other applications, any motion pattern within the mechanical limits of the table.

The table has an operating surface of more than 400 sq in., split into two levels, and is arranged so as to roll about its pitch axis. The maximum rate of rotation about both axes is greater than 100° sec, but to prevent damage to the units under test, provision is made for limiting the table's deceleration when it is driven into the resilient stops. In pitch the maximum deceleration is 6 g; and in roll, 4 g. The table has $\pm 30°$ of freedom about the roll axis and $\pm 28\frac{1}{2}°$ of freedom about its pitch axis.

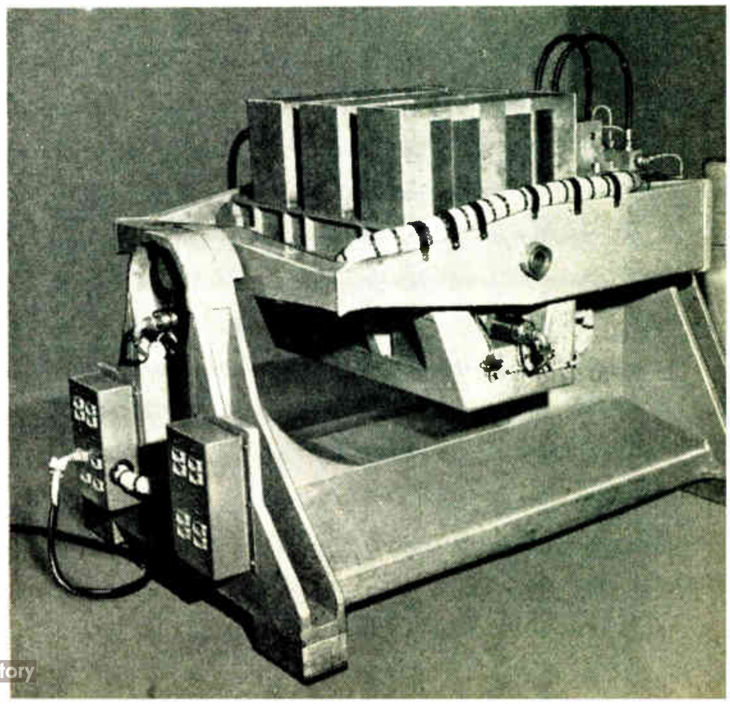
Control is by means of d.c. input to the servos which are capable of receiving a maximum signal of ± 100 V. In both axes the maximum threshold is less than the equivalent of an input signal demand for 0·05° table rotation. The frequency response characteristics are good, with very high accelerations in response to step function inputs, combined with stability of the table.

Equipment connections are provided in the form of two 'looped' looms of fixed wiring carrying 480 electrical leads.

The production version of the rocking table will have, in the standard model, a single operating surface 22 in. × 22 in. capable of handling equipment up to the weight of 100 lb. There will be less load inertia than on the 'Belfast' unit and thus an improvement in performance.

In cases where the surface area of the standard model is insufficient for a customer's requirements, Shorts can design and supply a special two-layer work table similar to that of the 'Belfast' unit. As an alternative to the standard 2-axis table, a 3-axis model is offered—the third axis being normal to the plane of roll and pitch. The 3-axis unit will have a working table $20\frac{3}{4}$ in. in diameter.

The electronic amplifiers, control and stabilized power supply units for each model are contained in a separate cabinet. All rocking tables are fitted with hydraulic accumulators to supply high transient hydraulic demands, but the main hydraulic supply is from a separate pump set.



By D. P. HOWSON,* M.Sc.

conversion loss in RECTIFIER MODULATORS

Continuing the discussion of rectifier modulators, this part of the article deals with the effect of negative feedback on stabilizing conversion loss.

Concluded from page 51 of October issue

As was mentioned in the introduction, the analysis in this section will be restricted to that form of feedback modulator in which the signal-frequency component at the output is fed back via a buffer amplifier to the input. This necessarily rules out the use of ring or other double-balanced modulators, as these do not produce a component at signal frequency at their output terminals.

The previous paper on this topic[5] established that under ideal conditions it was possible completely to stabilize two forms of modulator against both changes in r_b and r_f. To approach this desirable condition, however, it is necessary to have a high gain buffer amplifier, and a modulator with terminating impedances a long way removed from optimum, so that it has considerable loss. This work considers the effect of parameter changes in more detail in order to see what practical use can be made of this form of feedback. It is influenced by experimental results obtained by J. C. Gardiner, who found, using this system of feedback, that the conversion loss of the modulator he had built could be stabilized against changes in r_f or r_b, but not against both. These conditions will now be investigated theoretically, to determine if any modulators can be made which will stabilize against changes in both parameters, and to find out which circuit leads to the most practical feedback modulator.

Modulator with Constant-Resistance Terminations

From previous work[6] it is known that the currents at wanted product frequency and at signal frequency in this circuit are given by

$$\frac{i_1}{V} = \frac{1}{\pi}\,\frac{r_b - r_f}{R^2 + R(r_b + r_f) + r_b r_f} \qquad (13)$$

$$\frac{i_0}{V} = \frac{R + \frac{1}{2}(r_b + r_f)}{R^2 + R(r_b + r_f) + r_b r_f} \qquad (14)$$

where it is assumed that the wanted product is the first-order lower sideband. The formula for the first-order upper sideband is identical. In both cases no account has been taken of the fact that the wanted sideband current is 180° out of phase with the signal current since this does not affect the validity of the analysis but merely makes it more difficult to follow.

If this modulator is to be used in a feedback circuit, such as Fig. 2 in which a voltage proportional to the current i_0 is fed back to the signal source, then it is

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important to determine how i_0 varies with respect to i_{1-} when r_f and r_b are changed. Accordingly, differentiating (13) and (14),

$$\frac{\partial i_{1-}}{\partial r_f} = -\frac{V}{\pi}\frac{1}{(R+r_f)^2} = \frac{2}{\pi}\frac{\partial i_0}{\partial r_f} \qquad (15)$$

$$\frac{\partial i_{1-}}{\partial r_b} = \frac{V}{\pi}\frac{1}{(R+r_b)^2} = -\frac{2}{\pi}\frac{\partial i_0}{\partial r_b} \qquad (16)$$

Changes in r_f therefore produce corresponding increases or decreases in i_0 and i_{1-}, but in contrast changes in r_b increase the one while decreasing the other. Using conventional feedback, therefore, it is clearly possible to stabilize i_{1-} and therefore the conversion loss to some extent against changes in r_f, but the addition of feedback will worsen the effect on the conversion loss of changes in r_b. However, to determine the percentage changes in the parameters it is necessary to consider di_0/i_0 and di_1/i_1 for variations of r_f and of r_b. These expressions may be readily formed from the preceding equations, and it is found on examination that the percentage change in i_{1-} is always larger than that in i_0 for variation of r_f, tending to equality only when the terminating resistance $R \ll r_b$. Under this condition, however, changes in r_b have little effect on the modulator conversion loss anyway, so that by using sufficient feedback in this way the modulator conversion loss is relatively unaffected by changes in either parameter. Table 2 illustrates these effects for selected component values and Fig. 11 shows some experimental results. (These were little different from the corresponding theoretical results.) The following physical argument seems to support the above theory. If r_f is increased, because there is a greater resistance in the circuit i_0 will decrease. However, the efficiency of the rectifier is also diminished, since its reverse-to-forward resistance ratio is less, and so i_{1-} decreases. On the other hand if r_b is increased by the same argument i_0 will diminish. Now, however, the rectifier is more efficient, so that the modulation product, i_{1-} will *increase*.

The corresponding shunt modulator by duality will stabilize against changes of r_b but not against changes of r_f. For the latter effects to be negligible it will be necessary to have $G \ll g_f$; i.e., $R \gg r_f$. In practice it appears that if it is only desired to stabilize against temperature change this latter condition will not be necessary, as for many carrier generator circuits there will be little change in r_f. A note on duality is included in the Appendix; its effect as stated above has been verified experimentally.

Modulator with High or Low Impedance Terminations to Unwanted Products

From the first part of the article it seems clear that the only types of modulator with behaviour radically different from the constant-resistance modulator with respect to parameter changes are those mentioned in the heading above. Moreover, it is clear from Fig. 5 that it is possible with these modulators to reverse the sign of $\partial i_{1-}/\partial r_b$. This is important, as it is clear from the last section that this will allow the modulator conversion loss to be stabilized against both changes in r_f and r_b. However, a combination of circumstances make these types of circuits of little use in this context. It is found that the amount of feedback required to stabilize against changes in one parameter is relatively small, and varies for different values of the parameter. A large amount of feedback is required to stabilize against changes in the other parameter, so that in practice it is impossible to produce a circuit which will work well for the two forms of change. Variation of the mark/space ratio of the switching signal improves the position a little, but still does not make possible the design of a satisfactory circuit.

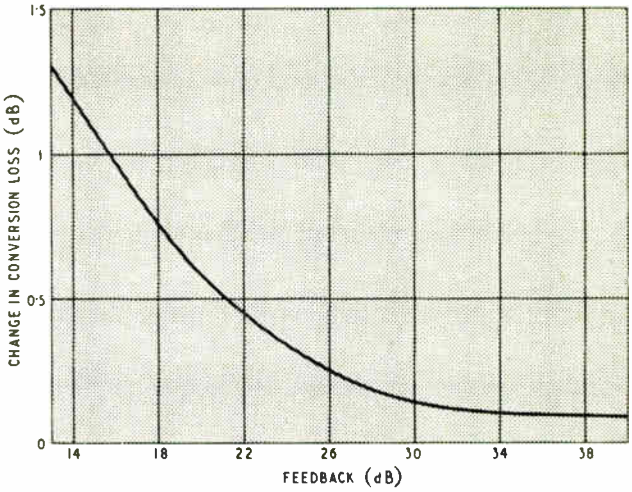

Fig. 11. Effect of feedback on a constant-resistance modulator

Conclusions

Modulators may be divided into two groups by the manner in which their conversion loss changes when the parameters of the time-varying resistance are changed. The first, or normal group, includes most types of modulators, as can be seen from inspection of Figs. 4 and 7, and Table 1. Normal behaviour means that:

(i) When the modulator is terminated so that the conversion loss is a minimum, an increase in one parameter ($r \to ar$) or a corresponding decrease in the other ($r \to r/a$) gives rise to the same change in conversion loss.

(ii) The graph of the change of conversion loss for change of one parameter against terminating resistance is a mirror image of the graph for a change in the other parameter, about a line drawn through the optimum resistance.

(iii) The substitution of a more efficient rectifier with the same mean value of resistance (ρ) makes the modulator less sensitive to changes in either parameter.

(iv) An increase in the terminating resistance renders the modulator more sensitive to changes in the reverse resistance, and similarly a decrease to changes in the forward resistance.

Abnormal behaviour is confined to modulators with both terminations either high or low to unwanted products. For these:

(i) The modulator is highly sensitive to changes in one parameter and quite insensitive to changes in the

TABLE 2

n 100

Terminating Resistance	Normal C.L. (dB)	Change in Rectifier Resistance	Change in i_0 1:x	Change in i_{1-} 1:x	Change in C.L. (dB)	Change in C.L. with Feedback (dB)
ρ	10·1	r_f · 10	0·928	0·93	+0·6	+0·02
		$r_b \div 10$	1·09	0·92	+0·6	+1·4
$\rho/10$	10·8	r_f · 10	0·549	0·55	+5·2	+0·02
		$r_b \div 10$	1·06	0·992	+0·07	+0·17

$$V' = V\left\{\frac{Z_l}{Z_s+Z_l}\right\}_0 \qquad Z' = \frac{Z_s Z_l}{Z_s+Z_l}$$

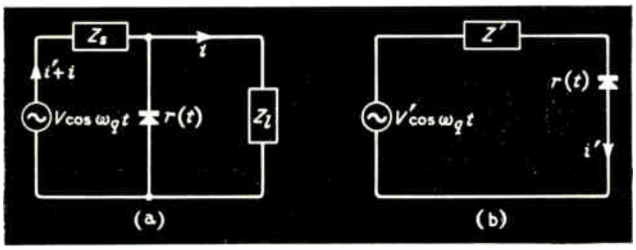

Fig. 12. Single loop equivalent circuit for the shunt modulator

other, over the whole of the practical range of terminating resistance, as can be seen in Fig. 5.

(ii) The substitution of a more efficient rectifier reduces but little the sensitivity of the modulator to changes in the one parameter, but renders it even more insensitive to changes in the other.

(iii) If the mark/space ratio of the switching signal is changed until the minimum conversion loss possible for this form of modulator is reached, then the behaviour becomes more normal.

(iv) A change in the parameter to which the modulator is highly sensitive may produce either an increase or a decrease in conversion loss depending on the value of the terminating resistance.

The possibility of stabilizing conversion loss against temperature change by selecting the most suitable terminating impedances was considered. It was shown that whereas this was quite feasible for small changes, over the normal range of ambient temperature little improvement was to be expected.

The use of feedback at signal frequency on single-balanced modulators with normal behaviour will allow the conversion loss to be stabilized against changes in one parameter only. However, it is possible to choose values of terminating resistance so that the modulator is insensitive to changes in the other parameter, and under these conditions a satisfactory circuit may be obtained.

If a modulator with abnormal behaviour is used in such a feedback loop it is possible to stabilize the conversion loss to some degree against changes in both parameters. However, due to the increased sensitivity of these modulators to changes in one parameter, and due to the different amounts of feedback required for each parameter, these circuits are not very practical and the former type is to be preferred.

Acknowledgments

The author is indebted to Mr. J. C. Gardiner of this department, whose work on the constant-resistance feedback modulator led to a real understanding of the circuit. Thanks are due also to Professor D. G. Tucker for his interest and encouragement.

APPENDIX

Equivalence of Series and Shunt Modulators

Mention has been made[6] of the representation of the shunt modulator by an equivalent single-loop circuit, as in Fig. 12. It is clear that the general equation for this equivalent single loop is

$$\left(\frac{Z_l}{Z_s+Z_l}\right)_0 \cdot V = i'\left(\frac{Z_s Z_l}{Z_s+Z_l} + r(t)\right) \qquad (17)$$

and that this bears a direct relationship to the corresponding equation for the series modulator of Fig. 3

$$V = i(Z - r(t)) \qquad (18)$$

so that the properties of i' can be deduced by analogy with the properties of the current in the series modulator. However, the current that is of primary importance in the shunt modulator is not i' but the current through the load which has been called i. This is related to i' by the equation

$$i(Z_s + Z_l) = V - i'Z_s \qquad (19)$$

which on evaluation at signal and wanted product frequencies, gives

$$i_0 = \frac{1}{(Z_s+Z_l)_0} \cdot (V - i_0' Z_{s0}) \qquad (20)$$

$$i_{1-} = -\left(\frac{Z_s}{Z_s+Z_l}\right)_{1-} \cdot i'_1 \qquad (21)$$

Thus, if the only concern is for the current at wanted product frequencies it is clear from equations (17), (18) and (21) that there is a direct relationship between the load currents in series and shunt modulators with the same terminating impedances. However, equally from (20) it is clear that there is no such relationship between the load currents at signal frequency. Therefore for feedback applications of the type under discussion, it is clear that this type of equivalence will not lead to corresponding series and shunt modulators performing in the same way when subjected to feedback at signal frequency. This is also true for feedback at wanted product frequency since here again the interest is in the *insertion loss* of the modulator to this product which will require an equation equivalent to (20) for evaluation, in addition to the conversion loss.

If the series modulator that is the exact dual of the particular shunt modulator is considered, however, it is easy to show (see for instance Reference 6, Appendix 2) that both signal and wanted product components behave in an analogous manner. Thus from the relationships governing the current i_0 and i_{1-} in the series modulator may be deduced the variations in the load voltages v_0 and v_{1-} in the shunt modulator, and vice versa. This has been verified experimentally in feedback circuits, for it was found that a series modulator with constant-resistance terminations stabilized only against changes in r_f and not against those in r_b: the corresponding shunt modulator with constant-resistance terminations showed exactly the opposite trends as would have been predicted from the above.

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By R. E. MARTIN, M.I.E.E., D.F.H.

Remote alarm for

Installing the transmitter, which in this instance is used with a Yagi aerial

unattended plant

This article describes an economical low-power v.h.f. radio transmitter utilizing the existing mobile radio network and capable of automatically sending telegraphic or speech alarm signals from outstations. In the Electricity Supply and Gas Industries there are very large numbers of such unattended outstations at which switching, transforming or pumping plant forms a link in the complex chain of distribution from producer to consumer. Such equipment may find applications other than these described, such as in water distribution, railways, police and fire alarm pillars, in navigational buoys and in flood warning devices.

IN the Electricity Supply Industry there are many instances where the condition of remote equipment is not known until a loss of supply is reported. For example, in a single Electricity Board there may be 12,000 circuit breakers[1], the operation of any one of which is not known until consumers report a failure of supply. Delay in restoration of supply can be costly in goodwill and may be a serious matter for consumers, particularly in industry and in some types of livestock production. In this latter case, small rural substations or even pole transformers may be involved. There are other cases where loss of supply and costly damage to equipment might result from ignorance of an alarm condition, such as in the use of oil- or gas-pressure cables. In all these instances it is without doubt desirable to have alarm facilities, but whether it is essential can only be decided by balancing the cost of failure against the cost of the alarm system ; not forgetting that the cost of failure might include danger to human life. The provision of cheaper alarm equipment should therefore result in its more extensive use, with a consequent increase in efficiency of the industry concerned.

Due to the very widespread nature of the distribution networks and the large geographic areas covered from a given manned control centre, the transmission of information existing at the many outstations is becoming of greatly increasing importance. Complex telegraphic supervisory equipment has been available for this purpose for many years and modern developments in solid-state digital electronic techniques using radio or line links have been demonstrated as a further solution to this problem[2,3,4,5,6,7,8]. However, such systems set out to provide a number of two-state indications (breakers, or valves, open or closed) and a number of analogue quantities (volts, amperes, stocks, pressures or flows) each telemetered, either on demand or automatically, when some change occurs. These schemes are therefore relatively costly, which results in their use being confined to the supervision of only the more important stations.

In the Electricity Supply Industry failures at a small transformer station, feeding one or more consumers, or even at an individual consumer's premises, are often not detected until the consumers complain. Owing to the very large number of such transformer stations, any suggested device must, of necessity, be simple, reliable and economical. It should preferably be self-contained and require virtually no maintenance.

On the high-voltage transmission networks, simple alarm requirements exist on plant such as oil- or gas-pressure cables where the pressure failure detecting element is located at one or other cable terminal which may itself be remote from a manned point.

In both cases the alarm conditions are very infrequent, probably arising only once in several years, so that it is most desirable to use a communication channel which will not lie idle during the intervening period. In the past, pilot cables or rented telephone lines have been employed but over distances greater than four or five miles, a radio link can be cheaper. In many remote areas it is impossible or uneconomical to provide pilots or telephone lines and radio is then the only alternative.

Underground pilot wire cable laid at the same time as power cables may cost around £1,000 per mile but if separate excavation and reinstatement has to be carried out, the costs may be £1,500–£2,500 per mile. Rented telephone circuits (2-wire Tariff 'S') cost about £24 per mile per annum for the lengths being considered for alarm purposes. The radio alarm costs between about £100 and £400 installed depending on the type of power supply, signal and housing if production quantities can be made at one time.

The majority of possible users have already got v.h.f. radio coverage from manned base-station control points so the alarm transmissions can conveniently be made on the existing mobile-to-base frequencies where such coverage exists.

Owing to the need to economize in the use of radio frequencies and having regard to the relatively infrequent operation of the alarm, the equipment is thus designed to operate on the mobile transmitter frequency of the v.h.f. radio system in use in the particular area. In the U.K. a number of channels are allocated for use in the Electricity and Gas Industries and are arranged on a geographic basis[9].

The present alarm system therefore requires no extra radio frequencies and in fact makes a fuller use of existing allocations.

The equipment comprises a compact fully-transistorized transmitter, having an output of 200 mW, which is automatically energized under alarm conditions. The transmitter can be supplied for indoor or outdoor (watertight) mounting and will operate for a few hours from its self-contained sealed battery. The latter can be arranged for automatic recharging from the local 240 V a.c. supply or, as in the model illustrated, it may be recharged by the action of daylight on a set of solar cells.

Signalling Requirements

If not many individual alarms (say, not more than two or three) are required within the coverage area of one base receiving station (typically 15–20 mile radius), the transmissions can be coded with 'pips' of tone. Both the 'pips' and the carrier are keyed to minimize interference with speech from mobile stations. By having a different tone frequency or pip repetition frequency for each of the installations, the base station operator, even if unskilled, can identify the individual alarm concerned. This system is most suitable for the oil- or gas-pressure cable alarm where operation is very infrequent and the transmission of simultaneous alarms from two or more locations is unlikely.

An alternative version, which will be more applicable to Electricity Board and Gas Board schemes, will incorporate a pre-recorded speech message announcing the name of the substation repeatedly for a period of one to five minutes. This version utilizes the same transmitter but the 'pip-pip' modulator assembly is replaced by a miniature tape reproducing unit.

It will be noted that, in both versions, no extra equipment is needed at the base station receiver as the operator already exists to 'decode' speech messages arriving from mobile stations. Mobile stations can also hear the alarm message directly in the case of single-frequency working schemes and can also hear it in the case of two-frequency working schemes where talk-through is employed[9].

A problem peculiar to the Electricity Industry application lies in the possibility of receiving two (or even more) alarms from different outstations simultaneously. For example, if the transmission is initiated by auxiliary switches on circuit breakers, two stations may send simultaneously if a power line trips at both ends.

This factor is taken into account in the design of the voice version by incorporating a pre-set delay between initiation and commencement of the transmission.

By having different delay settings at each installation, and also by appropriately limiting the duration of transmission of each equipment, simultaneous initiation at two or more points will result in sequential emission of voice alarm messages from each station in turn.

The brief alarm messages may, of course, occur during speech transmission from a mobile station and as a result interference could occur. However, as the substation name or other message is repeated over a period of a few minutes before being switched off, the base station can easily instruct mobiles to remain silent so that the alarm place name or names can be noted.

Description of Equipment

The requirements for the radio transmitter itself are principally utmost reliability coupled with compliance with the relevant G.P.O. specifications[10]. The first models were designed for use in the 71·5–88 Mc/s band and are capable of use with 25-kc/s channel-spacing schemes. Although the Electricity Industry will require amplitude-modulated units to be compatible with the majority of existing installations and the trials have been made on an a.m. basis, there is no difficulty in providing a corresponding f.m. version for which designs are already available. The transmitter output is limited to about 200 mW which with a suitable aerial and adequate path is capable of an effective range of at least 20 miles.

In the installation illustrated the closing of an external alarm switch connects the transmitter to the self-contained battery via a pair of wires connected to the equipment. The transmitter then delivers an r.f. signal to a 4-element Yagi aerial via a 70-ohm coaxial feeder.

The signal consists of a succession of half-second bursts of tone-modulated carrier (or 'pips') at three-second intervals. This signal is easily recognized and does not interfere with the normal working of the mobile v.h.f. radio network. The time interval between the pulses and the frequency of the tone modulation may readily be changed to provide identification of different stations.

The transmitter is transistorized throughout thus reducing the size, weight and power consumption to about 0·5 W. The power supply is obtained from a battery of sealed nickel-cadmium cells contained in the transmitter case. The battery is maintained at a constant voltage by the bank of 40 solar cells which charge it during daylight hours through a transistor voltage regulator. The solar cells can bring a fully discharged battery up to working condition in three days during mid-December and any loss of electrolyte or gassing is avoided by limiting the charge at a suitable voltage.

The apparatus is contained in a completely sealed cast aluminium box which is fitted with a desiccator to take up any condensation.

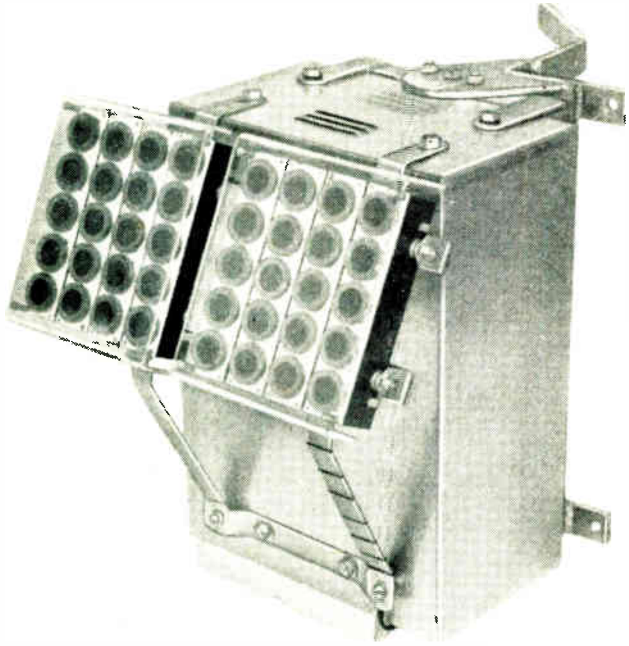
The solar battery consists of 40 silicon cells connected in series to the charge-regulating circuit which is designed to restrict the current when the storage battery voltage rises to 11·2 V. Due to the infrequent use of the equipment and the fact that the only load normally on the battery is its own internal loss, it is usually fully charged. The nickel-cadmium battery has a capacity of 3·75 Ah at the 1 hour rate and uses eight sintered plate cells.

While the model illustrated is arranged for outdoor watertight mounting and employs solar energy, the identical electronic units can be mounted in a case suitable for indoor use together with a battery charger to replace the solar cells. This version may be more convenient for use in small substations, kiosks and feeder pillars where the apparatus may be housed in dry conditions and where a mains supply is available to maintain the miniature battery automatically in charged condition.

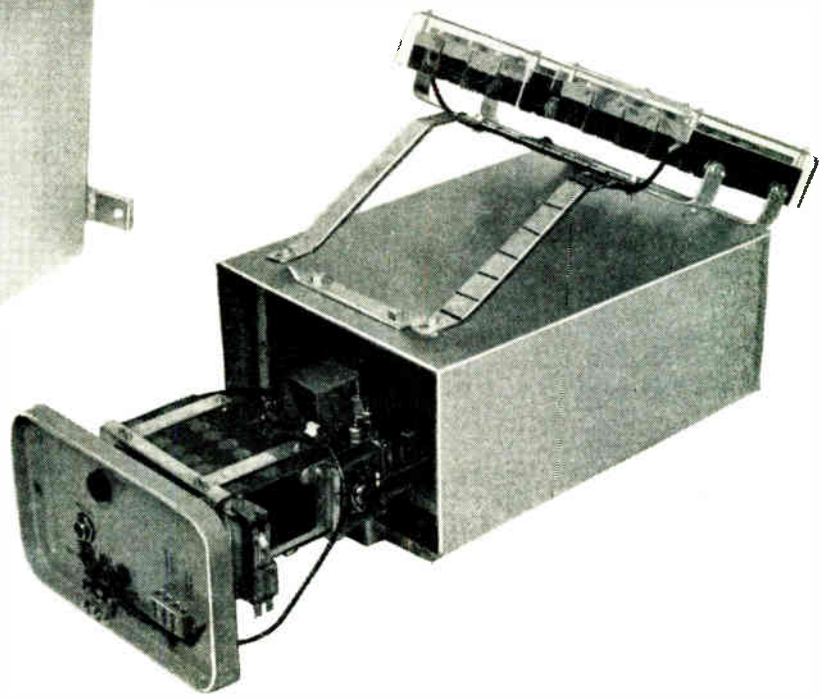
The alarm signal may be initiated by one or both of two means. In the installation illustrated, closure of an external circuit (by the low oil-pressure alarm contacts) energizes the transmitter which continues to operate until the circuit is re-opened manually or until the battery is discharged. This starting circuit can also be used to signal operation of a circuit breaker by connection to the necessary auxiliary contacts.

A relay is incorporated for optional use, either to isolate the equipment from circuit breaker auxiliary wiring, or to provide a 'mains failure' alarm. In the latter case the equipment can be employed at a small substation, kiosk or pole transformer, the 240 V a.c. supply serving to maintain the battery and also to hold the relay operated. On conditions of mains failure, the relay is released to energize the transmitter and send the alarm signal.

Experience has shown that the reliability of the equipment is excellent, but at the installation illustrated, a test push-button is connected in parallel with the initiating gauge contacts. The push-button can be operated from ground



Left : External view of the transmitter showing the bank of solar cells



Right . The transmitter partially withdrawn from its case

level although the transmitter assembly is, of course, mounted near the top of the tower.

An alternative to the manual test button would be to employ the solar cells in accordance with an ingenious suggestion made by Mr. H. C. Spencer of British Telecommunications Research Limited. The solar cells commence charging the battery at dawn and cease at dusk so a ready-made time switch exists to initiate a short period test transmission twice per day. A simple circuit can be added to give this facility where required.

The whole of the weatherproof version, including the battery, is mounted in a sealed cast metal box which is further surrounded by a radiation shield of bright anodized aluminium to reduce the temperature rise due to direct sunlight. The space between the sealed box and the shield is open below and free air circulation is permitted by the use of louvres at the top. The unit performs correctly over the temperature range −20 °C to +50 °C.

The cast box bolts directly to a special bracket fabricated from galvanized steel which enables the unit to be clamped to the angle iron legs of transmission-line towers. The bracket allows for an adjustment in azimuth exceeding 90° so that the solar cells may be directed towards geographic South regardless of the position of the tower. The bracket is also provided with two lugs to accommodate a vertical coaxial dipole aerial. The aerial connects directly to the transmitter via a short length of coaxial cable. Where directional properties are needed, as in the installation illustrated, a Yagi aerial can be used for which a separate mounting is available.

Both the 'pip-tone' and the speech versions use the same transistorized transmitter unit which can be arranged to operate either in the 70- or 170-Mc/s bands using either an a.m. or f.m. system of modulation. The trial units give 200 mW output into 75 ohms in the 70-Mc/s band and employ a.m. in order to be compatible with existing base station receivers. The transmitter circuit uses an oscillator with a series-mode crystal, a buffer amplifier, a driver and an output stage. Each stage uses a single transistor except the output stage, which has three transistors in parallel. A further transistor acts as a switch in the buffer amplifier circuit to cut off the carrier in accordance with the output of the modulator. The modulator assembly for the 'pip-tone' version is mounted on a separate card which facilitates replacement with the miniature tape speech-reproducer mechanism where required.

The 4-transistor modulator comprises a Colpitts type audio oscillator followed by a drive amplifier and a final push-pull amplifier which modulates the collector supply of the final transmitter stage.

A conventional multivibrator employing two further transistors keys the transmitter buffer amplifier to produce 0·5-second tone plus carrier bursts every three seconds.

Tests have shown that over a temperature range of −20 °C to +50 °C the frequency change was less than 3 kc/s total and the output power remained constant within ±1 dB. The harmonic levels in the output were checked up to the tenth and found to be below the permitted level of 2·5 μW. These and other tests have been carried out to obtain G.P.O. approval for the transmitter design, thus ensuring trouble-free integration into the system and providing an adequate degree of protection against interference with occupiers of adjacent channels.

In the voice alarm version now under development the modulation amplifier will be retained but the audio oscillator will be replaced with a source of pre-recorded speech on a short looped length of tape. The initiating contact (either external or an internal mains-failure relay) will start the tape transport motor which, in turn, actuates a sealing contact to maintain operation. The motor drives a blank length of tape for a pre-determined period of a few minutes after which a foil on the tape switches the transmitter on. This radiates the message previously recorded on the tape. At the conclusion of the message the transmitter is switched off.

To avoid repeated alarms resulting from one initiation, it has been decided to incorporate a manually controlled reset device. This will allow staff investigating the alarm to reset the equipment by depressing a push-button. Since the duration of the tape loop will only require a few minutes and the highest speech quality is not required, the size and complexity of the mechanism can be greatly reduced by moving the tape at only 3¾ in. per second.

Conclusion

Experience with the transistorized transmitter employing tone signalling has been most satisfactory and there is no reason to believe that there will be any difficulty in completing the development of the tape reproducer for modulating the same transmitter with speech. It is likely that the later transmitters will be even simpler due to the availability of improved transistors.

As the two forms of transmitter fill a long felt need in the Electricity Industry, their more widespread use should allow economical production. This will enable them to be applied to a variety of transforming and switching points so as to contribute to a saving in time and wasted journeys by staff and to the improvement of reliability in the supply.

The gas and the water distribution networks also have a number of uses for the device in the signalling of unattended booster or pump failures, holder or reservoir low levels, etc. Since no power supplies or long pilot cables are needed, the costs are reduced to a minimum.

It is also apparent that the equipment could give the police, ambulance and fire services a means of installing alarm push-buttons on street pillars without cable laying, signalling directly into the appropriate control centre or, if desired, directly to mobile stations.

A similar application under development in the U.S.A. provides for alarm pillars alongside highways. In this case more complex digital signalling is advocated as a method of sending one of several messages from each pillar and individually identifying the appropriate outstation.

Other possible applications lie in the signalling of river water levels, tide levels and flood conditions for river boards and harbour authorities, as well as the provision of alarms on aircraft-collision-warning lights located on high buildings, radio masts and high-voltage transmission-line towers.

Navigation buoys employing gas illumination could be fitted with the equipment to announce automatically in voice to shipping or a shore station at intervals if the light became extinguished.

Although the equipment described has been designed specifically for use in the Electricity Industry, it is hoped that it could also be employed for some of the purposes outlined above.

Informal discussions at C.I.G.R.E. and studies made in the U.S.A.[11] have emphasized the need for an alarm equipment such as that described.

The transmitter was developed for the Central Electricity Research Laboratories by British Telecommunications Research Limited and the author is indebted to Mr. J. Lawton, Director of Research, British Telecommunications Research Limited and to the Central Electricity Generating Board for permission to publish this article. He also wishes to express his thanks for assistance in the preparation of the article to Mr. H. C. Spencer and Mr. R. J. Millership of British Telecommunications Research Limited. Mr. J. Hooper and Mr. A. W. Wyness arranged the field trials.

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[8] J. A. Arnold and R. J. Grosch, 'Solid State Telemetry for Remote Control', A.I.E.E. Paper No. CP62–278.

[9] E. H. Cox and R. E. Martin, 'Radiocommunication in the Power Industry', *Proc. I.E.E.*, Vol. 108, Part A, No. 38 (April 1961).

[10] G.P.O. Private Mobile Radio Services (Nos. W6288 and W6289; Performance Specifications).

[11] Report of the Technical Representatives of the Joint Radio Committee of the Nationalized Fuel and Power Industries on their Visit to the U.S.A. and Canada, January 1960. C.E.G.B. London.

MARINE RADAR

Argus is the name of a new marine radar system recently introduced by The Marconi International Marine Co. Ltd. It provides a display which can be stabilized either 'Bows Up' or 'North Up' and the change from one to the other can be made merely by operating a switch.

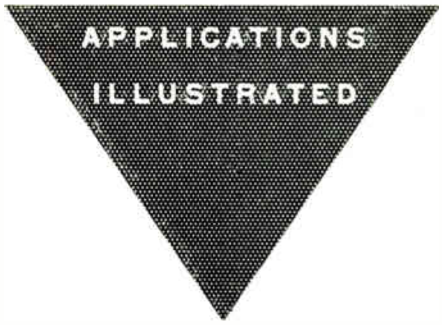
The display is at all times compass stabilized. As usual, the bearing ring is stabilized, but in addition the tube is also. With a change of course the tube rotates so that in the 'Bows Up' display the present course of the ship is always vertically upwards on the tube face. If the course is changed the tube and whole radar picture rotate to maintain this condition and the display picture turns about the ship position just as the real view appears to do.

The equipment thus gives the navigator the choice of two true-motion pictures at all times. A 12-in. p.p.i tube is used and the aerial is of the slotted waveguide type rotating at 25 r.p.m.

The transmitter power is 70 kW and display ranges of ¾, 1½, 3, 6, 12, 18, 24 and 48 miles are provided. The display unit is connected to the transmitter and receiver by cable which can be up to 1,000 ft in length.

A more conventional radar set is the Hermes. This is designed to be compatible with the Argus and the two can be operated from a single aerial, transmitter and receiver. An Argus with stabilized display can be fitted in the wheelhouse, for instance, and a Hermes as a second display in the chartroom.

For further information circle 46 on Service Card



Two-way radio telephone

IN every business good communications are essential for efficient operation and, therefore, flexibility in a communication system must bring about an improvement in efficiency. Shown here is a series of pictures that illustrate applications of the Cossor 'CariTel' portable two-way radio telephone. This is a battery-operated, transistor equipment which is simple to use and weighs less than 7 lb. It provides clear two-way speech communication over ranges of 1 to 5 miles between mobile equipments and 1 to 10 miles between a fixed base station and mobile equipments.

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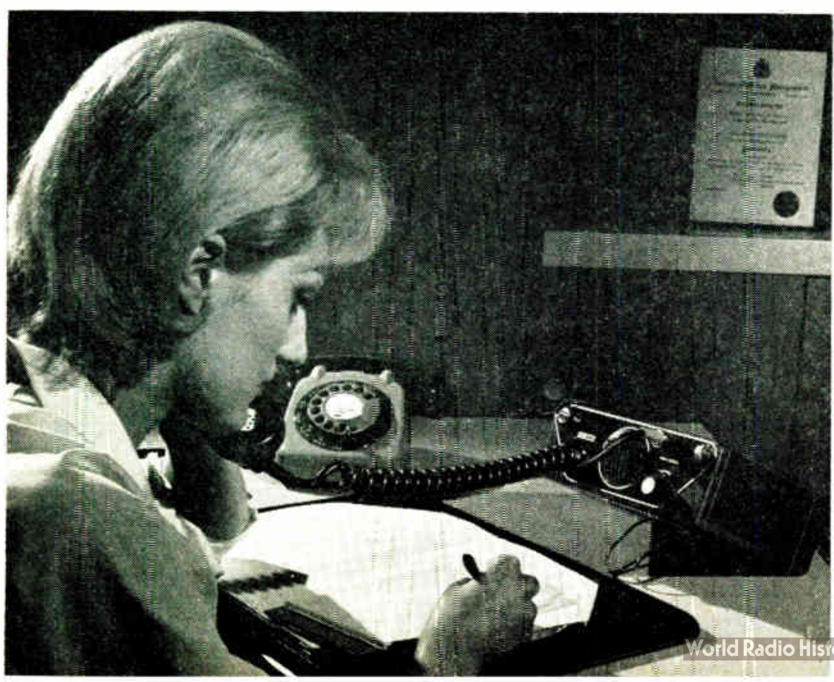


Thermoelectric Cooling

By J. E. BEAN *

A MODERN approach to many cooling problems lies in the application of thermoelectrics. While the efficiency of thermoelectric cooling devices is not comparable with that of compression refrigeration units, it does compare favourably with that of absorption types, and where the maximum cooling power required is of the order of tens of watts (1 watt = 0·239 calorie/sec) thermoelectric cooling devices have an unrivalled potential. In specialized applications thermoelectric units having cooling powers in the kilowatt range have been used.

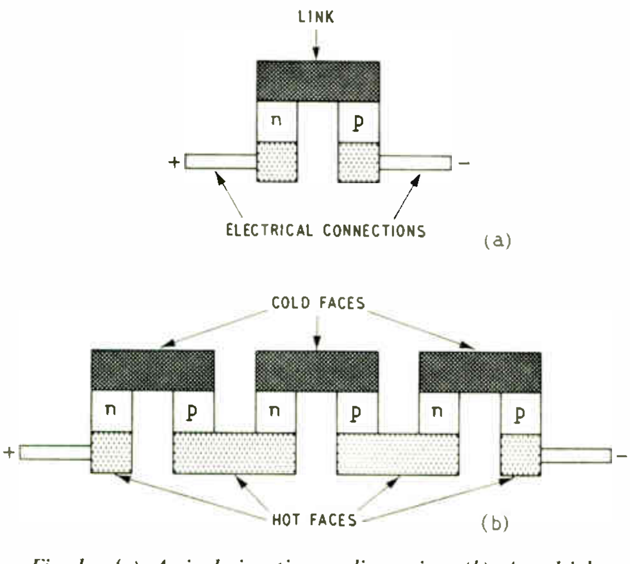


Fig. 1. (a) A single junction cooling unit. (b) A multiple junction cooling unit

Production of practical thermoelectric cooling devices has been made possible by comparatively recent advances in solid-state physics. Semiconductors having far better thermoelectric characteristics than the best found in metals have been developed, the outstanding ones being alloys of bismuth and tellurium modified by the addition of other elements. These alloys are grouped under the general heading of bismuth telluride, Bi_2Te_3, which is produced in both p and n types. Development of manufacturing techniques has resulted in the production and marketing of a range of commercially attractive thermoelectric cooling units. A selection of the units manufactured by Salford Electrical Instruments Ltd. is illustrated in the photograph. The smallest unit consists of a single p-n couple of bismuth telluride in which the p and n elements are bonded together with a heavy link of pure tin as shown in Fig. 1 (a). The larger devices are constructed from a number of similar couples connected electrically in series. In such multiple units the couples operate thermally in parallel, as in Fig. 1 (b). The dimensions of the single-junction unit are 0·25 in. × 0·25 in. × 0·5 in., and its nominal cooling power is 0·25 watt while maintaining a temperature difference of about 30 °C between its opposite faces. Instruments incorporating these cooling units are manufactured by the same company.

Principles of Operation

The operation of thermoelectric-cooling devices is based on two closely inter-related phenomena known as the Peltier effect and the Seebeck effect respectively, each of which is an inversion of the other.

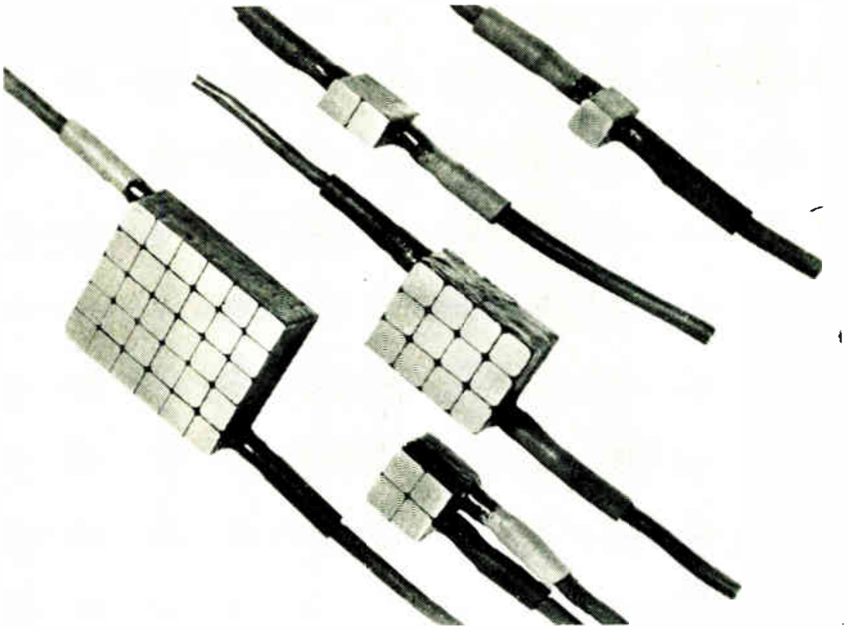
Peltier Effect

A thermocouple (or simply a 'couple') is a closed-circuit formed by two dissimilar materials, A and B. In such a circuit there is inevitably a point at which any circulating current passes from A to B, and one at which the current passes from B to A. These two points are called the 'junctions'. When a direct current flows around such a circuit heat is absorbed at one junction (the cold junction), and released at the other (the hot junction). This phenomenon is called the Pelter effect, and the couple itself may be regarded as a heat pump.

Reversing the direction of the current also reverses the hot and cold junctions. Breaking the closed circuit to insert

* Salford Electrical Instruments Ltd.

For long a textbook curiosity, the Peltier effect has become a practicable method of small-scale refrigeration. This is a consequence of the development of semiconductors, and very compact units are now available; one of volume about 0·03 cubic inch will give a heat transference of about 0·1 calorie per second.



Selection of thermoelectric cooling units

a source of direct current, or inserting a third material between a junction does not affect the phenomenon. Any number of couples may be connected electrically in series, in which case each individual couple in the circuit exhibits the same phenomenon.

The heat released at the hot junction by the Peltier effect is distinct from, and additional to, the Joule heat dissipated in the region of the hot junction, which is proportional to resistance and the square of the applied current; but the Joule heat dissipated in the region of the cold junction has to be transferred to the hot junction by the action of the Peltier effect. The Joule heating, therefore, places a limitation on the effectiveness of a couple used as a heat pump. The pumping efficiency of a couple is further limited by its thermal conductance, which allows heat to flow back from the hot junction to the cold one. Further references to these points are made under 'Figure of Merit'. All couples have a Peltier coefficient (π) which (when measured under standard conditions of temperature) is defined as the amount of heat absorbed (or released) per second at a junction of dissimilar materials when unit current flows through it.

Seebeck Coefficient — α

The Seebeck coefficient is related to the Peltier coefficient by the expression $\pi = \alpha T$ where T is the temperature in °K.

The Seebeck coefficient of a material is defined as the e.m.f. in volts per °K generated across a junction of the material with a standard metal, usually lead. The sign of the Seebeck coefficient may be either positive or negative, according to the direction of polarity of the e.m.f. generated across the junction. The overall Seebeck coefficient for a junction of two dissimilar materials is the difference between the coefficients of the two materials used. Since the Seebeck coefficient of a material or a couple is more readily determined than the Peltier coefficient, the Seebeck coefficient is generally used in calculations related to thermoelectrics.

Figure of Merit

All materials investigated for use in thermoelectric cooling devices are given a figure of merit (Z), which takes into account its Seebeck coefficient, specific resistance, and specific thermal conductance. The figure of merit indicates the usefulness of a material in thermoelectric applications, the higher the figure of merit, the better the material. The figure of merit of any material is given by the expression:—

$$Z = \frac{\text{Seebeck coefficient}^2}{\text{Specific resistance} \times \text{Specific thermal conductance}}$$

Thermoelectric effects were first observed in metals, but their advantage of very low values of specific resistance is heavily offset by the correspondingly high values of thermal conductance and low values of α, so that the resulting figures of merit are too low to be of practical value. It is for this reason that thermoelectric cooling was for so long regarded as no more than a laboratory curiosity. In the newly-developed semiconductor alloys the high values of α which are available are partly offset by the product of resistance and thermal conductance, which also tends to be high; but the resulting figures of merit are still good enough to make thermoelectric cooling a practical proposition.

Overall Figure of Merit of a Junction

The overall figure of merit for a junction of two dissimilar materials may be taken as the mean of the individual

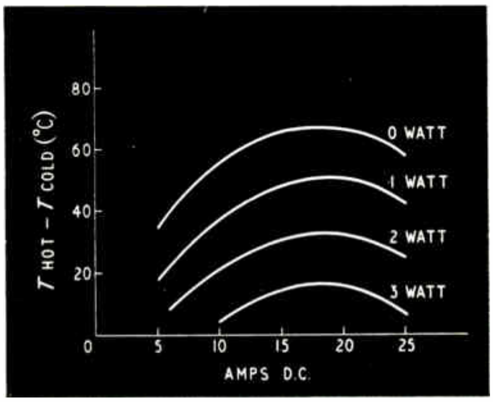


Fig. 2. Characteristics of a BT.4 unit operating under ideal conditions

figures of merit of the materials used, and provided that the two figures are not widely different the error will be small. The best overall figure of merit for a junction is obtained when the Seebeck coefficients of the materials used are of opposite sign, as is the case with p and n types of semiconductors.

Development of Materials

Although the basic physics of semiconductor materials is well known it is impossible to predict with any accuracy the performance of new materials before they have been manufactured. Consequently there is no reason to assume that bismuth telluride (which is currently the best material for use between temperatures of about −80 °C to +180 °C) is the ultimate material for use in this application. Materials having figures of merit of just over 3×10^{-3} per °K have been produced but are not available in quantity. Bismuth telluride alloys having figures of merit of between $2{\cdot}5 \times 10^{-3}$ per °K and $2{\cdot}9 \times 10^{-3}$ per °K can be produced consistently and are used in most of the thermoelectric-cooling devices offered for sale.

Performance of Practical Cooling Units

If there were no losses in a practical thermoelectric-cooling unit the watts of heat absorbed at the cold face (that is, the useful cooling power) would equal the product of the Seebeck coefficient, the current in amperes and the temperature of the cold face in °C. In practice, there are two kinds of loss which must be deducted to arrive at the true cooling power.

The first is the Joule heating loss. One-half of the total Joule heat is dissipated towards the cold side of the device and has to be removed by the Peltier effect. The loss is, therefore, $\frac{1}{2} I^2R$ where R is the sum of all electrical resistances in the unit. Poor bonding of the links between semiconductor elements introduces resistance and increases Joule heating.

The second kind of loss is due to heat leakage across the unit from the hot side to the cold via the thermal conductance K of the unit. This amounts to $K\Delta T$ where ΔT is the temperature difference across the unit. Now K is the sum of all the thermal conductances in the unit, not only of the semiconductor elements from which it is made. Bad constructional design and methods of mounting create thermal shunts across the unit and so increase the heat leakage from the hot to the cold side. Such defects can result in the production of inefficient units even although the figure of merit of the constituent materials may be very good.

Using materials with a figure of merit of $2{\cdot}5 \times 10^{-3}$ per °C, and with a mean temperature of 10 °C, a temperature difference of about 75 °C can be achieved between the hot and cold junctions of a thermoelectric couple. With a figure of merit of 3×10^{-3} per °C this temperature difference is increased to 90 °C, but it must be appreciated that these figures represent the no-thermal-load condition with the element in vacuum and screened by radiant heat shields. It will be seen later that these temperature differences cannot be maintained in practical applications.

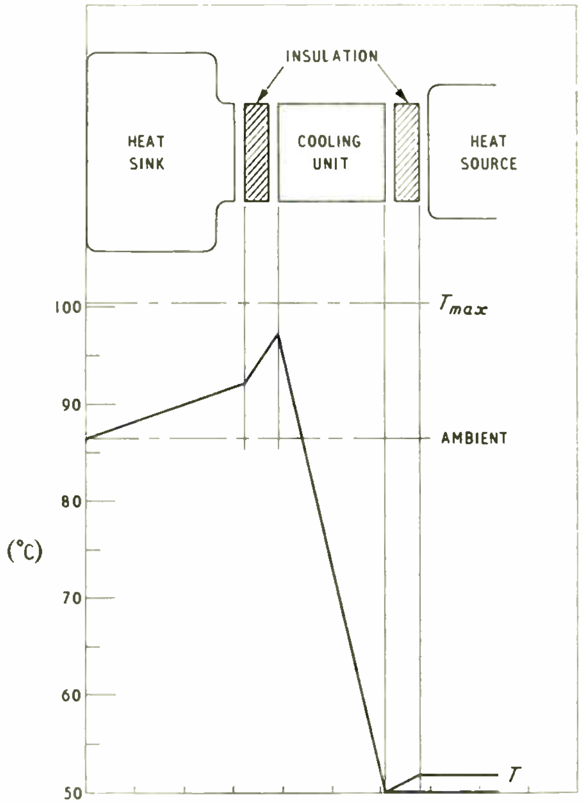


Fig. 4. Illustration of thermal gradients across a practical cooling assembly

So far as the potential user is concerned a thermoelectric cooling unit takes the form of a small block fitted with a pair of electrical connectors. If these connectors are coupled to a suitable source of supply and a direct current is passed through the unit, heat is absorbed at one face (termed the 'cold face'), and is transferred to the opposite face (termed the 'hot face'). Reversal of the direction of the applied current also reverses the hot and cold faces. Transfer of heat between the two faces results in a temperature difference being set up between them, and the magnitude of this difference may be varied simply by adjusting the value of the applied current, which makes this type of device particularly suitable for use in proportional-control systems.

The unit may, therefore, correctly be regarded as a heat pump, in which changes of electron entropy may be compared with the changes of state of the refrigerant in a compression or absorption-type heat pump. The thermoelectric cooling unit may be thermally coupled to some mass or confined space and used to pump away heat, thus producing a temperature depression. The relationship between the applied current, and temperature difference for various values of heat load on a four-couple unit is illustrated by the family of curves shown in Fig. 2.

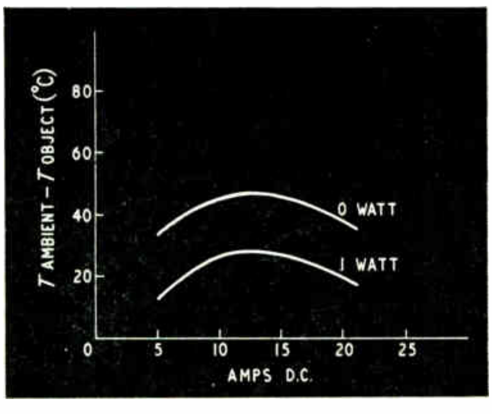


Fig. 3. Characteristics of a BT.4 unit operating in a practical assembly

The total amount of heat generated at the hot face of the unit comprises the heat watts absorbed from the environment at the cold face of the unit, plus the power input of I^2R watts. In order to dissipate this heat without incurring a serious rise in the temperature of the hot face of the unit, the hot face must be coupled to some form of heat exchanger, or heat sink. In practical applications the cooling unit will therefore be clamped between the mass to be cooled (i.e., a heat source) and the heat sink. In order to achieve the most efficient transfer of heat between the component parts of the assembly the thermal coupling must be as tight as possible, but the exposed electrical links on the faces of the cooling unit must be electrically insulated to prevent short-circuiting by the mating faces of the heat sink and heat source. This inevitably introduces some thermal resistance, which creates a thermal gradient between the mating surfaces and reduces the temperature difference which can be set up between the heat source and ambient. The effect of thermal resistance in a practical cooling assembly can be seen by comparing the curves in Fig. 2 with those shown in Fig. 3, and is shown diagrammatically in Fig. 4.

Current and Voltage Ratings

The majority of thermoelectric cooling units commercially available are high-current–low-voltage (amps/millivolts) devices. In many applications, especially in electronic systems, low-current–higher-voltage devices would possess obvious advantages. For a given cooling power the number of pairs of elements required is inversely proportional to the optimum value of the applied current. Thus, a four-couple device with a nominal cooling power of 1 watt operating at 10 amps and 500 mV could be replaced by a 40-couple unit operating at 1 amp and 5 volts. However, since the cost of a thermoelectric cooling unit is more closely related to the number of couples used than to any other factor, a low-current device is inevitably much more expensive than a high-current device of similar cooling capacity, although the production of such devices presents no major difficulties.

Coolers in Cascade

From the curves shown in Fig. 2 it can be seen that, for a given thermoelectric cooling unit there is a limit to the maximum temperature difference which can be set up between its faces, and this is reached only when the optimum current is applied and the heat load is zero. For a given heat load, the maximum temperature difference can be approached only by increasing the number of couples and distributing the heat load between them. Even so the temperature difference which can be achieved cannot exceed the limit determined by the type of unit employed. Temperature differences greater than the maximum indicated by the curves of Fig. 2 can be achieved only by operating two or more units in cascade (i.e., series thermal operation, in which the hot face of one unit is coupled to the cold face of a second unit, and so on, the hot face of the final unit being coupled to a heat sink). The temperature difference across the complete assembly is then the sum of the difference across the separate units. A heavy penalty is incurred in terms of cost and power input since the ratio of the cooling powers of the cascaded units in a practical assembly must be of the order of 1-5-25 . . . etc.

SMALL-SCALE DATA PROCESSOR

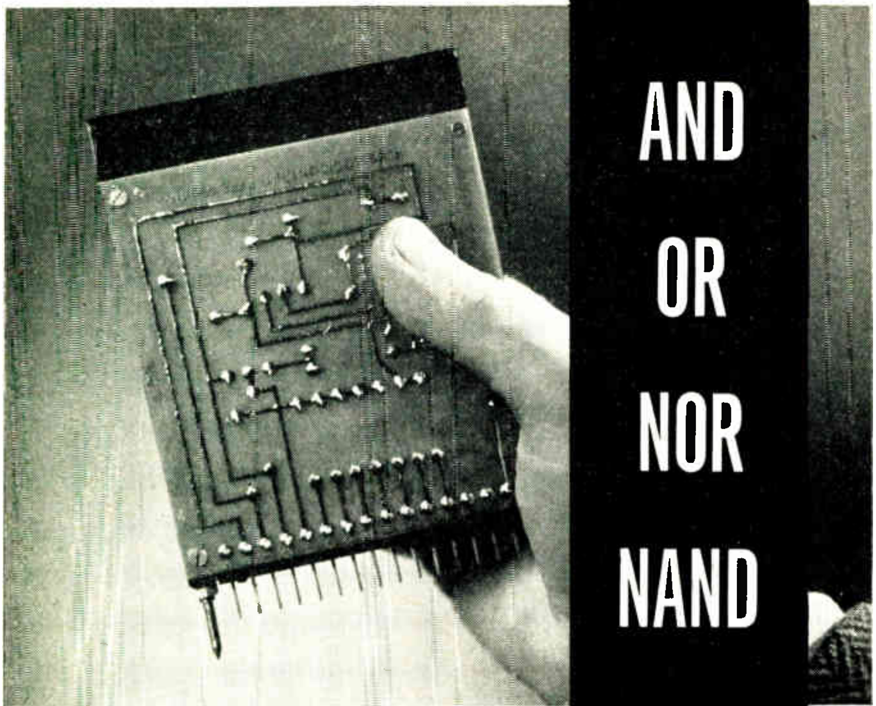
The National Sterling Compu-Tronic, which is a desk-size accounting machine, has been adapted for use in a small-scale data-processing system. The resulting system is being used by Walter Graham (Jewellery) Ltd., manufacturers and wholesalers of costume jewellery, in order to produce invoices, sales and purchase ledger, and a punched-tape record.

To prepare an invoice, the operator feeds into the machine the price and quantity of each item ordered by the customer. The machine then works out the total price of each item, taking purchase tax and discount into account, prints the results on the invoice form and totals them. At the same time it records the transaction on the customer's ledger card. An associated paper-tape punch also records the details on paper tape.

The equipment has cost about £6,500 and it enables one operator to do the work of six or seven invoice typists and eliminates many copying errors. In addition, it is now practicable to produce a monthly series of sales and stock reports. The paper tape is fed monthly to a National-Elliott 803 computer to produce an analysis of the daily sales data.

For further information circle 48 on Service Card

National-Sterling Compu-Tronic accounting machine with the associated paper tape punch apparatus



AND OR NOR NAND

This article explains the meaning of these logical terms which are now so widely applied to certain electronic apparatus used in computers and control equipment.

Typical printed-circuit plug-in static switching unit, the A.E.I. Logicon. Units of this kind, embodying semiconductor elements, are used to carry out the functions explained by switches in the article

THE words of this title are ones which are being increasingly used in the electronics industry. They must be incomprehensible to most people outside it, and it must be admitted that they are to many inside it! The fact is that these words are technical terms of logic; each refers specifically to some particular logical concept. The terms have been borrowed by electronic engineers to describe electronic apparatus which performs electrical functions which are analogous to logical concepts.

The apparatus itself is usually quite simple and so are the functions. Originally it formed some of the basic building blocks of computers, but as computer methods are being widely adopted in control systems they are now being used well outside the computer field.

And

An AND circuit or unit is very simple indeed. It is merely a unit which is controlled by a number of input signals and which provides an output only when all the input signals are present simultaneously. Thus, in Fig. 1 a battery with a pair of switches in series represents a simple AND circuit. The operation of closing switch A represents one input signal, that of closing B a second. There is no output if both switches are open (that is, no input signals). There is still no output if either A or B is closed (one input only). The output appears only when both A and B are closed.

Or

The OR circuit is equally simple, but as a trap for the unwary there is the fact that in logic and in electronics there are two kinds of 'or'. There are the inclusive 'or' and the exclusive 'or'. For two signals the first is exemplified by Fig. 2 (a). An output signal appears when one input signal is applied or when the other is applied or when both are present. As the circuit shows there is an output when either A or B is closed or when both are.

With the exclusive OR there is an output when either input is present *but not when both are.* Fig. 2 (b) shows an arrangement of switches which gives this condition. When both switches are to the right there are no input signals and no output. Moving either switch to the left corresponds to one input signal only and an output is obtained. But if both switches are moved to the left, corresponding to two inputs simultaneously present, there is no output.

Lest it should be thought that there is something peculiar about the two kinds of OR, it may be remarked that they occur naturally in everyday life, but most people do not

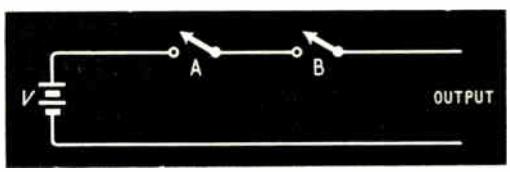


Fig. 1. A simple AND circuit; an output is obtained only when switches A and B are closed. By merely redefining what is meant by input and output it becomes a NOR circuit

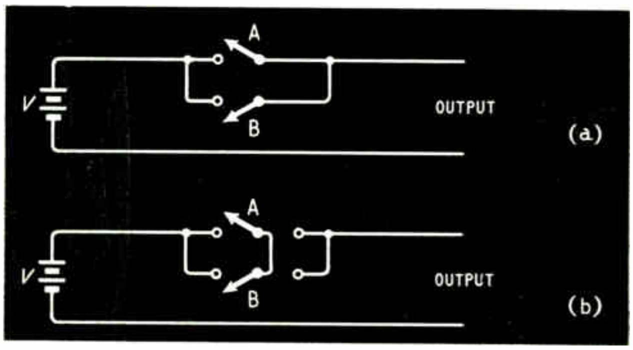


Fig. 2. An inclusive OR *circuit is shown at (a): an output is obtained if A or B or both are closed. An exclusive* OR *circuit is shown at (b); an output occurs if A or B is to the left, but not if both are. The circuit (a) becomes a* NAND *one if input and output are redefined*

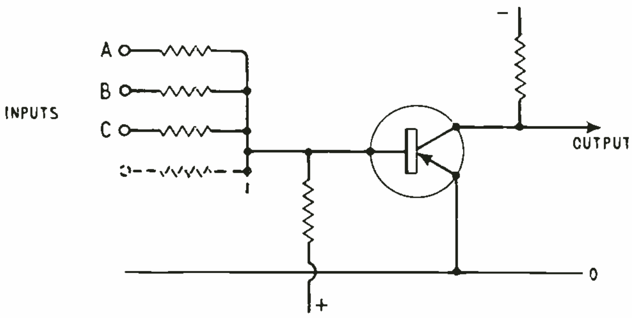


Fig. 3. This transistor circuit provides all four logical functions merely according to the precise definitions of input and output and an appropriate shift of the base bias voltage

consciously distinguish them. If one is told to 'sink or swim' one cannot do both simultaneously and the exclusive 'or' is necessarily meant. On the other hand, if one says 'If it rains I shall wear a coat or take an umbrella' the 'or' may be inclusive or exclusive, for it is perfectly possible to wear a coat and take an umbrella. That the exclusive 'or' is more common in ordinary life than the inclusive is shown by the fact that when the inclusive is meant the speaker will commonly add 'or both' to his statement.

In electronic circuitry, however, it is the other way round. It is the inclusive OR which is the more common.

Nor

A NOR circuit should obviously be one which provides an output when there are no input signals; that is, when there is an input neither at A nor at B. The AND circuit of Fig. 1 will do this if the condition of the switches being closed is regarded as one of no input and the opening of a switch as an input.

The normal no-signal condition is with an input neither at A nor at B and both switches are closed. The appearance of a signal at A or B or both corresponds to opening switches A or B or both and the output disappears.

An AND and a NOR circuit are thus identical; the difference is merely in the conditions of use.

Nand

As might be expected a NAND circuit is one which means NOT AND: that is, the circuit gives an output only if there is not a signal at one input and not a signal at the other input. In Fig. 2 (a) the input signals have hitherto been regarded as closing the switches and the output signal has been considered to be the appearance of the voltage *V* at the output terminals. Let us now reverse this as far as the output is concerned. Let us consider a voltage *V* at the output as being no signal and the disappearance of this voltage as an output signal. An output signal now appears only when both switches are open; that is, when there is *not* a signal on A *and not* a signal on B.

Transistor Circuit

It is a fact that one and the same circuit can provide AND, OR, NOR or NAND operation depending only on what are regarded as inputs and outputs. One such circuit is shown in Fig. 3. If all the inputs are connected to the zero line the transistor is cut off and the collector is at its most negative potential. If any one (or more) of the inputs is made sufficiently negative the transistor conducts and the collector potential changes in the positive direction. If we regard negative-going input voltages as input signals and a positive-going output voltage as an output signal, the circuit provides an OR function, for the transistor conducts to give an output only if there is an input at A or B or C, etc. On the other hand, if we regard the output signal as being provided by a negative-going output the circuit is a NOR one, for the output is negative only when there is a negative input neither at A nor at B nor at C.

Now regard the output as being a positive-going signal, and reduce the base bias so that when the inputs are joined to the zero line the transistor is conductive. NAND operation is now obtained for positive input signals. A positive output signal demands that the base of the transistor be negative, and this condition exists only when there is not a positive input at A and at B and at C.

If now the inputs are positive and we regard a negative signal as an output the circuit becomes an AND one. A negative output requires the transistor base to be zero which requires all the inputs to carry positive signals, as long as the bias is adjusted to make the transistor conductive with the input terminals joined to the zero line.

Thus the same circuit provides all four functions and the differences are merely whether we regard the input and output signals as positive or negative. A shift in the applied base bias voltage may be needed, but no change to the actual circuit. The differences between the four so-called modes of operation is really much more in the way of thinking about them, in the logic, than electronically, which accounts for the peculiar difficulty so many people seem to experience with them.

At the present time the NOR and NAND forms of operation are preferred to the OR and AND for the very simple reason that as the input and output signals are in each case of the same polarity one stage can drive another directly without intermediate phase reversers. A complete logical unit can be constructed from a number of identical sub-units.

Personal and Company News

Sir Gordon Radley has been appointed Chairman of Marconi's Wireless Telegraph Co. Ltd. in succession to Lord Nelson of Stafford. **F. N. Sutherland** has been appointed Deputy Chairman while retaining his position as managing director.

Ultra Electronics, Ltd. and **Eichner Organization G.m.b.H.** of Frankfurt now have a licence agreement covering the marketing and manufacture of Eichner equipment in the U.K. and the marketing of Ultra Automatic Business Systems in continental Europe. The agreement involves the investment by Ultra of £225,000 in Eichner.

The management structure of **English Electric Valve Co. Ltd.** has been changed. Dr. D. C. Thompson becomes assistant general manager and is responsible for internal company maintenance and service departments as well as the piece-part production plant and the Display-Tube Department.

A new division is under the management of J. Dain. It is the Microwave Tube Division, which now incorporates the older Radar Division, Magnetron Department and the Microwave Research Division.

E. Allard has been appointed Development Manager.

E. H. Miller has been appointed executive director of Coutant Electronics Ltd. and is in charge of transducer operations.

D. H. C. Scholes has been appointed Executive Director of The Plessey Co. Ltd. and Technical Co-ordinator for the Plessey Group of Companies.

The M-O Valve Co. Ltd. has appointed John Wallace, D.L.C. (Eng.) Hons., Production Director.

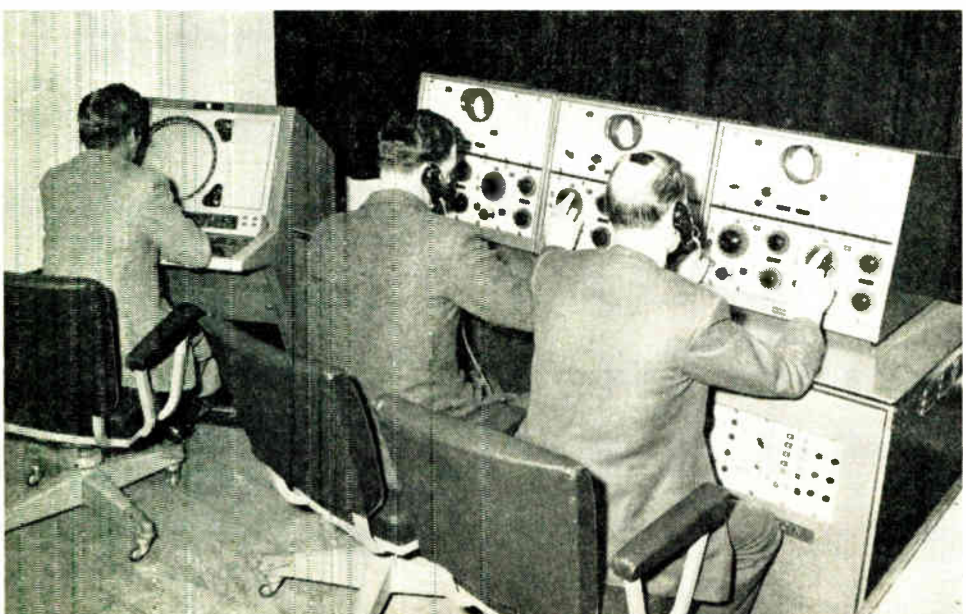
Aveley Electric Ltd. has appointed Paul Thomson, A.M.Brit.I.R.E., M.A.S.E.E., to investigate the needs of organized training in technical fields and to make recommendations for improvement of existing equipment or to evolve new systems.

High Precision Equipment Ltd. has concluded a licence agreement with **Baird Machine Co.,** U.S.A., for the manufacture in England of Baird multi-spindle chucking machines. The agreement also covers the marketing and provision of after-sales service for other Baird machines.

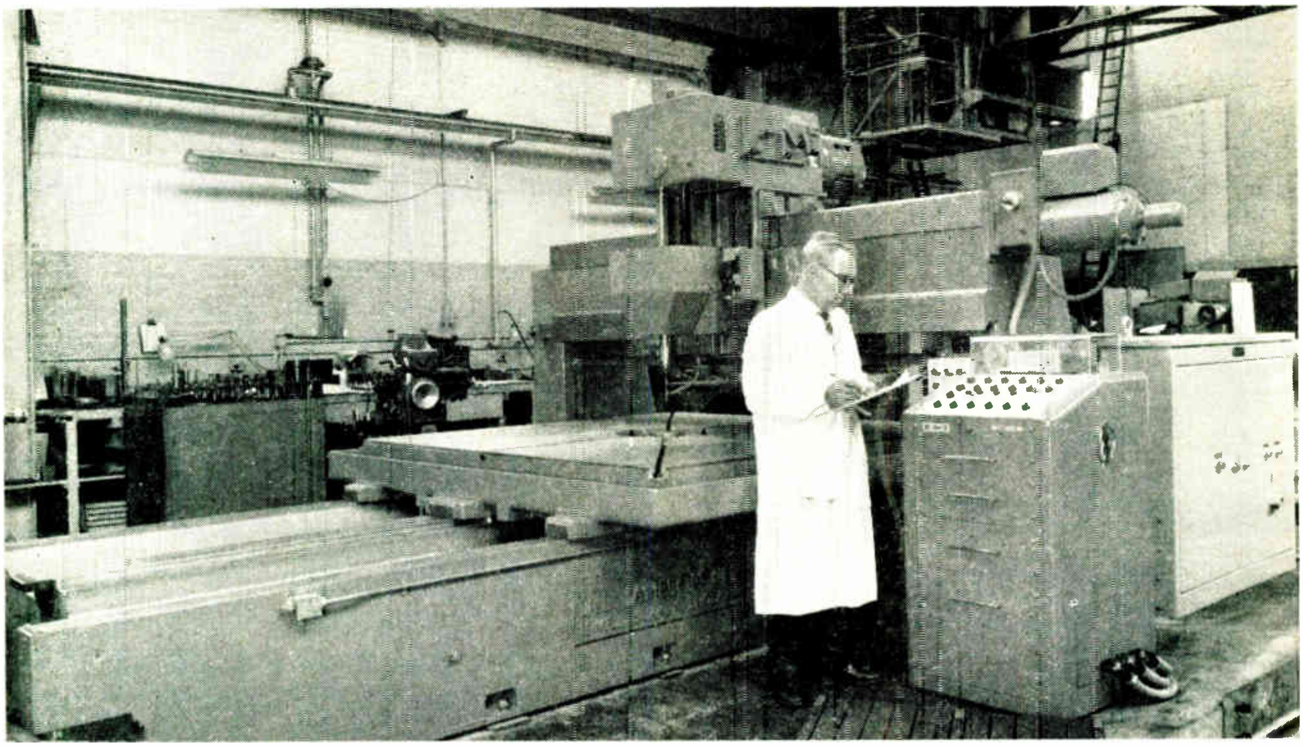
J. B. Goodacre of 55 Blacketts Wood Drive, Chorley Wood, Herts., has resigned his position as Commercial Manager with J. Langham Thompson Ltd.

Elliott Bros. Ltd. has been appointed exclusive technical products distributor for Fairchild Controls Corporation, U.S.A., in Great Britain and Eire.

A new service depot for **Murphy** radiotelephones has been set up at 398 Caledonian Road, Glasgow, C.5.



A Solartron radar simulator has been installed at the Jan Smuts airfield, Johannesburg. The picture shows two 'pilots' operating six 'aircraft' under instructions from the 'controller'. The simulated radar 'echoes' are being received by a pupil on a Marconi SD.701 display unit



A machine tool developed by J. L. Jameson Ltd., of Ewell, for drilling and reaming tube plates used in heat exchangers, condensers and boilers has now been adapted for numerical control by E.M.I. Electronics Ltd.
Operated by the EMICON B.100 analogue positional control equipment, this drill consists of a bed on which moves a flat work-table. A bridge across the work-table carries a motorized drilling head with its spindle feeding downwards. Both single and multi-spindle drilling heads are available. A total drilling area of 72 in. × 72 in. can be covered by the drilling spindle, and holes can be drilled in any position by co-ordinate settings of the two movements with an accuracy of 0·0005 in.

Miniature Electronic Components Ltd. has appointed Leslie G. Harrison as sales office supervisor and David C. Dance as company sales engineer for the South of England.

A.E.I. Automation Ltd., a new company formed to develop and supply systems of automation for industrial applications, has appointed J. L. Russell as managing director and L. S. Tredgett as commercial manager.

Alan Threlfall, A.M.I.Mech.E., Graduate I.E.E., has been appointed sales manager of the Numerical Control Division of Ferranti Ltd.

The main **A.E.I.** sales office in Sheffield is now at 19 Cumberland Street (Telephone: 20051).

J. B. Coleridge has become a director of Plessey International Ltd.

I.B.M. United Kingdom Ltd. have a new branch office at 1 Eastgate, Leeds.

John Ayres has resigned all his directorships within the group of Simms Motor and Electronics Corporation Ltd.

Partridge Transformers Ltd. of Roebuck Road, Chessington, Surrey, have changed their telephone number to Lower Hook 4353/4/5.

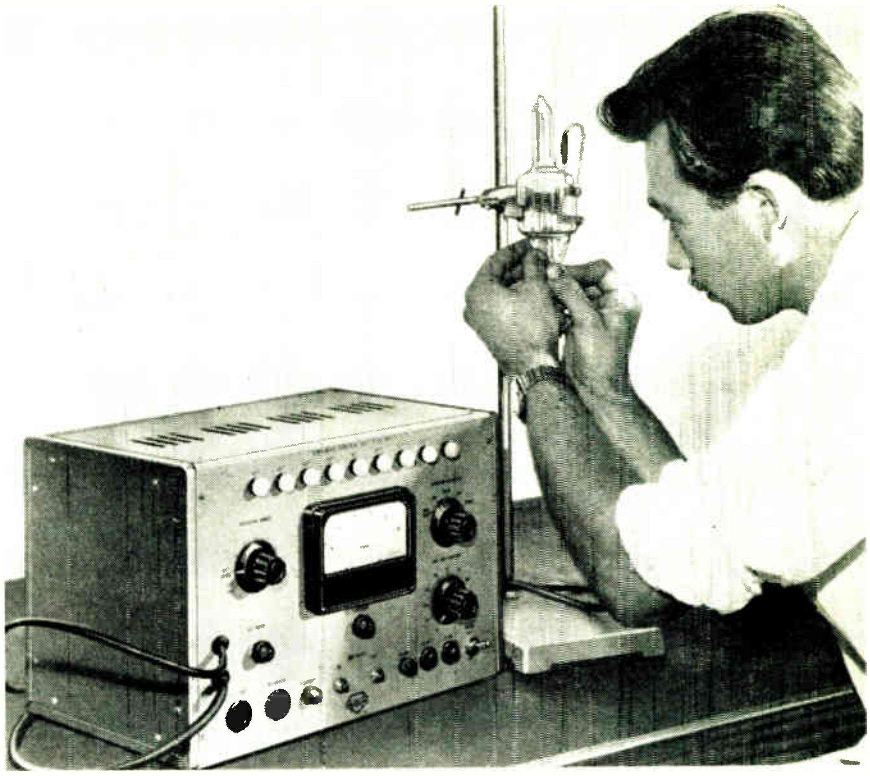
Cossor Radar & Electronics Ltd., a subsidiary of A. C. Cossor Ltd., has changed its name to **Cossor Electronics Ltd.** and Frank F. Oddi has been appointed chairman and managing director. Richard J. Yates, B.Sc., has become chief engineer of Instrument Operations of A. C. Cossor Ltd.

C. L. Hirshman, A.C.G.I., D.I.C., S.M.I.R.E., has been appointed engineering manager of Thorn-A.E.I. Radio Valve and Tubes Ltd. **J. C. King,** A.Brit.I.R.E., has become engineering manager, products development, a post which **J. Donegan,** B.Sc., A.C.G.I., D.I.C., relinquishes for special duties.

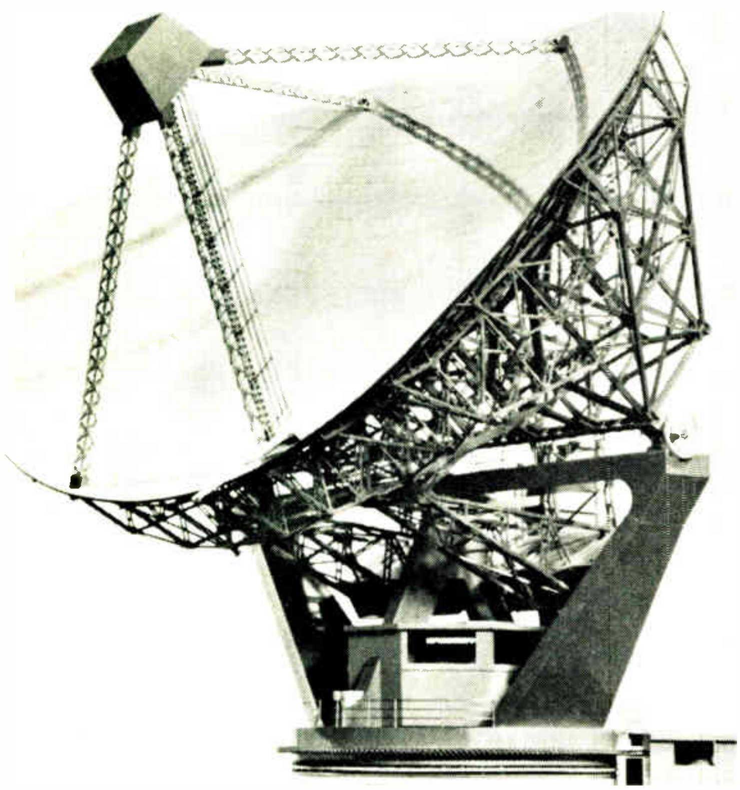
J. C. Smith has been appointed the technical representative for the North of England for Morganite Resistors Ltd. Address: 4 Martindale Avenue, Seaburn Dene, Nr. Sunderland.

The Distillers Co. Ltd. and **Union Carbide Corp.** of New York are bringing into joint ownership certain of their plastic interests in the U.K. The joint company will consist of British Xylonite, the low-density polyethylene operations of Union Carbide at Grangemouth and the present interest of Union Carbide in Bakelite Ltd.

Mullard Ltd. have appointed **Livingston Control Ltd.** (Retcar St., London, N.19: Archway 6251) as agents for Norbits, Combi-Elements and associated equipment.



Mullard WPS3 transistorized control unit for operating the IOG12 ionization gauge. A feature of the WPS3 is its very wide pressure range coverage from 10^{-3} to 10^{-11} torr. On all ranges pressure readings are taken directly from the meter. The order of pressure is shown by the illumination of one of the row of indicator lamps on the front panel



The photograph shows a model of the Mark II radio-telescope which is to be built for Manchester University and erected at Jodrell Bank. The contract for building and installing the machinery is for £74,320 and has been awarded to Sir William Arrol & Co.

Thin Insulating Films

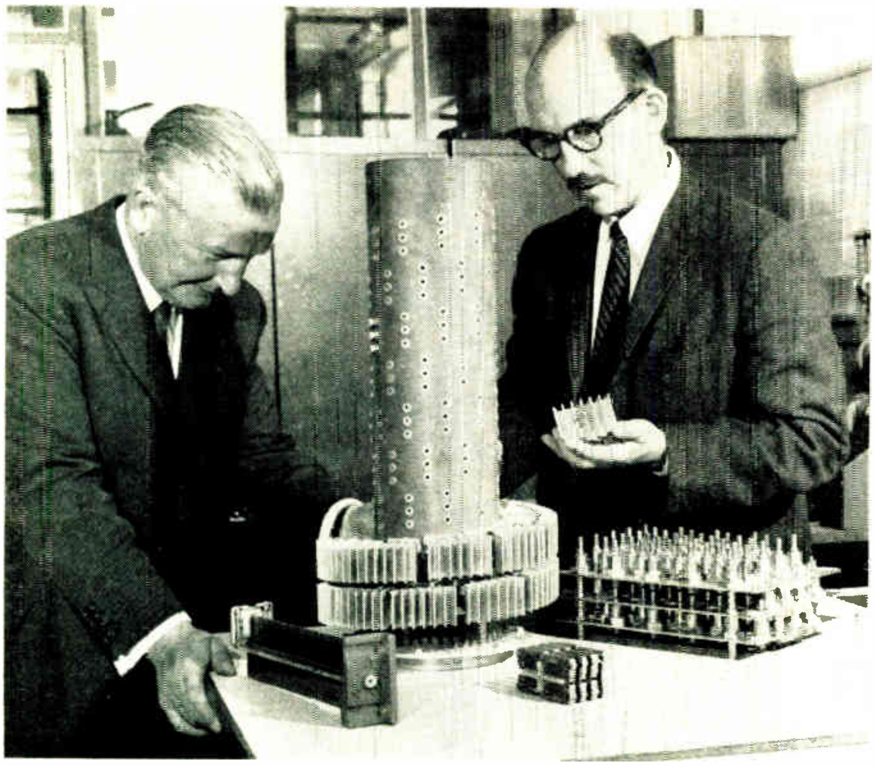
I.B.M. announce a new technique for forming very thin insulating films on solid material. An organic gas, butadiene, is polymerized into a solid insulating layer by bombardment by a beam of electrons. The polymerization occurs initially in an adsorbed layer on the surface of the substrate and as the film grows it continues by the reaction of the adsorbed gas with active sites on the polymer surface. It appears practicable to draw fine lines of insulating film on a surface by suitably deflecting the electron beam.

Measurement of Grain Size

The National Engineering Laboratory has developed a machine for measuring automatically the average grain size of metallurgical specimens. A photomicrograph is used and moved mechanically so that it is scanned by a beam of light. The optical path is interrupted at each grain boundary so that a photocell produces an electrical pulse for each boundary, and an electronic counter displays the total number of such pulses.

Electronics and Industrial Productivity

From 16th to 20th April 1963 the British Institution of Radio Engineers is holding a Convention on Electronics and Industrial Productivity. It will be held at the University of Southampton. Sessions are planned under five headings:—Measurement and sensing devices, Information transmission and Communication, Control and information processing, Output devices and final control elements, and Industrial applications of electronic systems.



A high-voltage rectifier column is now being manufactured at Oxted in Surrey by International Rectifier Company (Great Britain) Ltd., a company owned jointly by Metal Industries Ltd. and International Rectifier Corporation of Los Angeles, U.S.A.
Such rectifier columns find application in apparatus for electrostatic precipitation in steel mills and in other industries for by-product recovery from flue gas. They are also used for the American distant early warning system; in research into energy from nuclear fusion; and for television and radio broadcast transmitters

Pulse and Digital Circuits

The College of Advanced Technology at Birmingham has arranged a course in Pulse and Digital Circuits. The course is intended to provide basic principles of design and opportunities for the measurement of the performance of such circuits. It will be held on Tuesday and Thursday evenings, commencing 8th January next, and further details may be obtained from the Secretary, College of Advanced Technology, Gosta Green, Birmingham, 4.

Marine Radar

Following the introduction of the Hermes and Argus radars, by Marconi International Marine Co. Ltd., arrangements have been made for this company to offer on a rental basis only the Kelvin Hughes 14/9 and 14/12 radars to U.K. shipowners. Marconi Marine service facilities will be available.

7th International Instrument Show

Organized by B. & K. Laboratories Ltd. this show will be held from 27th-31st May 1963 inclusive at 4 Tilney Street, Park Lane, London, W.1. Admission is to be by ticket only. Coincident with it, there will be held the 1st Environmental Engineering Symposium. Those who wish to attend the symposium are requested to write soon to B. & K. Laboratories Ltd., 57 Union Street, London, S.E.1.

Interkamer

The next International Congress and Exhibition of Measuring Instruments and Automation will be 10th to 16th November 1965.

Superconducting Solenoid

What is believed to be the first superconducting solenoid constructed from niobium-zirconium alloy wire made in the U.K. was tested on Monday, 15th October, at the Nuclear Research Centre of C. A. Parsons & Co. Ltd., Newcastle-upon-Tyne. A small coil was wound from 100 ft of this wire and tests in liquid helium, at a temperature of 4 °C above absolute zero, yielded a maximum magnetic field strength of 16,000 gauss.

The wire, 0·01 in. dia., was fabricated at the Centre and formed part of the longest continuous length (300 ft) of this material produced so far in this country. Other portions of the wire have been forwarded to government and university research establishments for further testing.

Automatic Production Symposium

The Institution of Electrical Engineers will hold a two-day Symposium in October 1963 on Automatic Production in Electrical and Electronic Engineering.

It is proposed that there will be two parts, the first dealing with the design of components to facilitate the application of automatic production techniques, and the second concerning the design and operation of, and experience with, plant for the automatic fabrication and assembly of relatively complicated equipment.

National Radio Show

For the first time for many years there will be no National Radio Show in 1963. There may, however, be a trade show. Plans are being considered for a Show in 1964 when the first 625-line television transmissions on the u.h.f. band have begun.

Correspondence

Esaki Diode Decision Circuit

Sir,—We should like to draw your attention to an interesting application of the tunnel-diode twin.

A tunnel-diode twin, comprising two diodes with similar volt-ampere characteristics, Fig. 1, works in such a way that when increasing both supply voltages V_1 and V_2 the point A between both diodes remains for some time at potential $V_v = 0$. When, at time T, the voltages V_1 and V_2 reach the magnitudes V_p and $-V_p$ respectively, the differential resistance at point A increases to infinity. Therefore, at this moment, a theoretically infinitesimal current impulse is able to change the balanced state of the circuit. With a further increase of the supply voltages the operating point of one diode crosses the negative-resistance region, while the operating point of the other returns to the initial point of the characteristic.

Thus the potential V_v approximates after time T to V_1 or V_2, depending upon the polarity of the predetermining current impulse. This current at the instant T could be arbitrarily small if both characteristics were ideally congruent, disregarding the noise of the circuit.

In reality, if in the time T there is no predetermining signal from outside present, the noise decides between one of two stable states. So the probability of occurrence of both stable states is the same.

This phenomenon can be used for the construction of a random decision circuit; that is one which generates a series of randomly-following binary digits. The relation of occurrence of both stable states may be changed by the presence of a very small signal from outside. The amplitude may be less than the noise level. From the relation of the occurrence of both states, or from its changes, we can determined not only the polarity but also the magnitude of the signal.

The occurrence relation may also be influenced by resistances in parallel with both diodes.

On account of its great sensitivity, the whole circuit may also be used, when slightly adjusted, as a systematic-decision circuit for indicating the polarity of very low voltages or currents. The frequency of supply impulses is only limited by the cut-off frequency of the Esaki diode, and may be very high, of the order of hundreds of Mc/s. For this reason the systematic-decision circuit with tunnel diodes can be used in the comparison circuits of fast and precision analogue-to-digital converters, servos and voltage stabilizers. In many cases it may be a substitute for the Schmidt circuit and polarized relay. We have both carried out experimental work with the circuit. Both diodes had approximately the same characteristics with a peak current $I_p = 10$ mA, and were equalized by parallel-connected

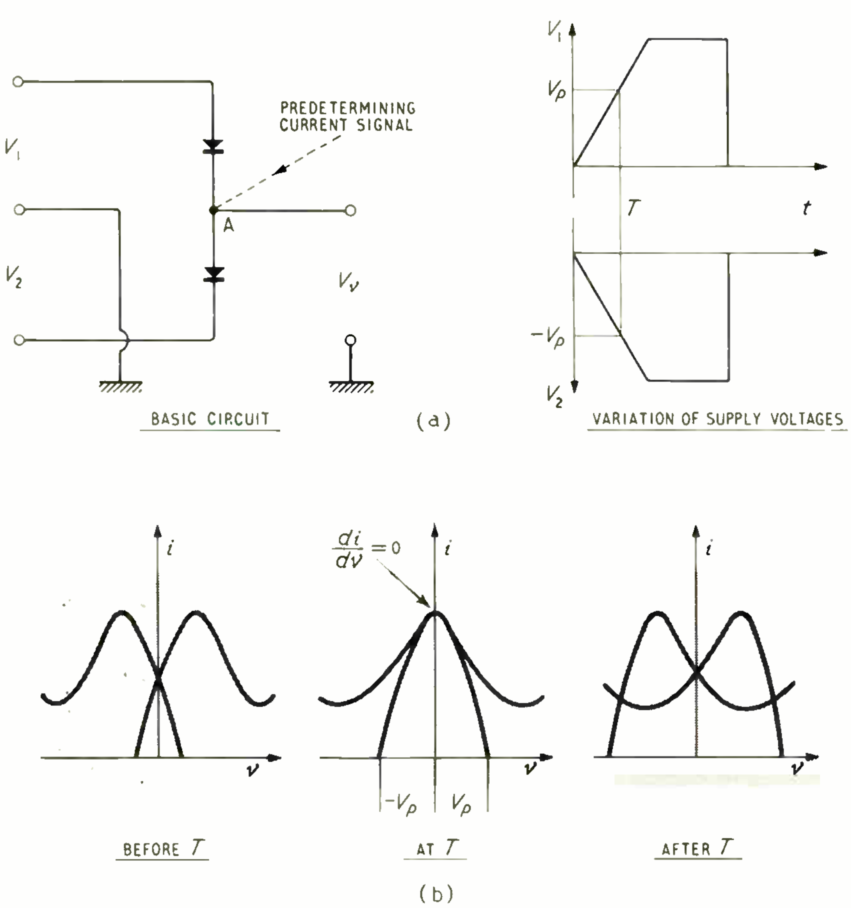


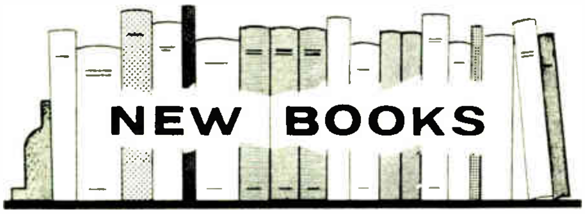
Fig. 1.—The diode circuit and characteristics are shown at (a) with three conditions of operation at (b). On the left the initial conditions are shown and in the centre the critical conditions reached with a rising voltage. Finally, on the right the final stable condition is indicated

resistors. A current of 1 μA was sufficient for systematic decision and we believe that the sensitivity of the circuit may be increased by using diodes of lower I_p.

We both wish to thank Mr. A. Marek for his kind assistance in our work.

JAN JANKU,
ZDENEK MALEC.

Institute of Mathematical Machines, Prague, Czechoslovakia.



Radio and Television Test Instruments

By GORDON J. KING, ASSOC.Brit.I.R.E. Pp. 175. Odhams Press Ltd., 96 Long Acre, London, W.C.2. Price 25s.

This book describes the kinds of instrument commonly used for servicing domestic radio and television receivers. It also describes, rather briefly, how to use them. It is an elementary book but one which should be very useful to the newcomer to the subject.

One incorrect statement was noted. It is said that 'the total power taken by any a.c. appliance can be determined by measuring the voltage and current and multiplying them together'. This is, of course, true only when voltage and current are in phase and are sinusoidal. Considerable error can occur with an a.c./d.c. set, because the h.t. rectifier can make the current waveform far from sinusoidal.

This is really a minor criticism of the book, for it is rare indeed for it to be necessary to measure the power consumption of broadcast receivers.

The Electronics of Laboratory and Process Instruments

By V. S. GRIFFITHS, Ph.D., F.R.I.C., and W. H. LEE, Ph.D., F.R.I.C. Pp. 368 + xiii. Chatto and Windus Ltd., 40-42 William IV Street, London, W.C.2. Price 50s.

The aim of this book is to provide those with a background of general physics with a working knowledge of the operation of electronic instruments used in chemical and control laboratories. The authors are on the staff of the Battersea College of Technology and have for some years included material of this nature in the courses for research students in physical chemistry.

The introductory chapter deals with components and their characteristics. The following chapter on alternating current actually deals mainly with rectification and the effect of resistance, capacitance and inductance in various combinations. The treatment is mathematical and vector diagrams are freely used, the j-notation being avoided. A chapter on tuned circuits, in which transformers are included, then follows, the treatment being similar.

Chapter IV is headed 'Thermionic Emission'. It contains little about this and deals mainly with the various kinds of valve and their characteristics. It is followed by three chapters on applications. In the first rectifiers and stabilized power-supply circuits are discussed, as well as the diode detector. In the second amplifiers are explained with the aid of the usual load-line diagrams, and in the third oscillators are treated.

There is a chapter on miscellaneous electronic tubes and one on transistors. The rest of the book is devoted to describing particular physical measurements of quantities such as conductivity of solutions, pH, polarography, etc.

The concept of the book is a good one and on the whole it is well carried out. It is unfortunate, therefore, that the book is marred by quite a number of errors. As a result of ignoring the effect of the reservoir capacitance, the way in which a rectifier operates is wrongly described and a similar mistake occurs in the case of the diode detector. Oddly enough, in dealing with the same effect for the grid-leak biasing of an oscillator the treatment is right! The ripple frequency for a half-wave oscillator is 50 c/s, not 100 c/s as stated. Class AB operation of a valve is wrongly defined and in the treatment of oscillators the word 'energy' is used where 'power' is meant. Quite a number of diagrams contain errors; for example, Figs. 6.15(a) and 7.2(a) and (b).

The book could be a very good one, but it needs thorough revision.

Junction Transistor Circuit Analysis

By S. S. HAKIM, Ph.D., B.Sc., A.M.I.E.E. Pp. 522. Iliffe Books Ltd., Dorset House, Stamford Street, London, S.E.1. Price 105s.

There are twelve chapters in this book and four appendixes. The first deals with the physical properties of the transistor and the second with small-signal equivalent circuits. After that biasing circuits and stability are treated. Chapters on single-stage, multistage and power amplifiers follow. These first six chapters occupy some two-fifths of the book and are followed by over 100 pages on negative-feedback amplifiers.

Tuned amplifiers, oscillators and negative-impedance convertors are the subjects of the next three chapters after which the book is completed with large-signal response and switching circuits.

Algebra is freely used, including matrix methods and the Laplace transform. The reader will not get very far unless he is thoroughly familiar with the ordinary mathematics of circuits; the more advanced mathematics occurs relatively rarely, but the reader will be in difficulty with, for example, multistage amplifiers unless he is fully conversant with matrices.

The treatment is very thorough and there are numerous worked examples. The book is essentially one for the designer.

Transistor Radios—Circuitry and Servicing

Prepared by the MULLARD TECHNICAL INFORMATION DEPARTMENT and issued by Mullard Ltd., Mullard House, Torrington Place, London, W.C.1. Pp. 72 + vii. Price 5s.

The first three chapters of this booklet deal with semiconductors and transistors and the fourth with printed wiring. Chapter 5 is a long one covering circuits, starting with the basic stages and ending with the complete diagram of an a.m./f.m. portable receiver. A chapter on servicing follows and, finally, one on test equipment.

The booklet forms a most useful guide to those unfamiliar with the practice of transistor receivers.

Information Theory and its Engineering Applications (3rd Ed.)

By D. A. BELL, M.A., Ph.D., M.I.E.E. Pp. 196 + viii. Sir Isaac Pitman and Sons Ltd., Pitman House, Parker Street, Kingsway, London, W.C.2. Price 25s.

This now well-known book is to be welcomed in its re-appearance as a third edition. There is no major change in it, but a review of error-detecting and error-correcting digital codes has been added and there is a new chapter on electronic computers and data-processing.

For the most part the book is non-mathematical and is very clearly written. There are places, however, where a knowledge of probability is necessary to a proper understanding. Much useful information can be gained without this knowledge, but it is necessary if one is to get the most out of the book.

Communal Aerials and Coaxial Relay Practice

By GORDON J. KING, ASSOC.Brit.I.R.E. Pp. 71. Gordon J. King (Enterprises) Ltd. 1962. 'Kingsford', South Furzeham Road, Brixham, S. Devon. Price 8s 6d.

This booklet is descriptive of television cable distribution systems and, in spite of the title, it contains very little about aerials.

How to Build Electronic Equipment

By J. RICHARD JOHNSON. John F. Rider Publisher, Inc., New York. Pp. 290 + vi. Price $6.95.

This is a very elementary book dealing with the mechanics of constructing electronic apparatus. It deals with useful hand tools and describes the kinds and sizes of screws commonly used (threads are American), it explains how to make a chassis and then treats component layout and wiring. It is essentially a book for the real beginner in such work.

An Introduction to Electric Circuit Analysis

By RALPH E. ARMINGTON and CARL VOLZ. Pp. 244 + xi. Prentice-Hall International Inc., 28 Welbeck St., London, W.1. Price 42s.

This is a serious and well-written book. The first half deals with electrical fundamentals from a circuit point of view, the second half covers methods of circuit analysis, ending with third-order systems. The ground covered is treated in countless other books but here there is not the complexity of mathematics which appears in so many and which is so deterring to the beginner.

It must not be inferred, however, that this book is non-mathematical. It is far from that; differential equations and Laplace transforms are freely used. There are few pages that are free from equations, and yet the result is not at all deterring.

Manufacturers' Literature

Preformed Wiring and Accessories. This brochure, publication No. 425, gives details of the Plessey preformed wiring service and describes the advantages of preformed wiring. Also illustrated are several ancillary items including cubicles, electronic control systems and sheet metal enclosures.
The Plessey Co. (U.K.) Ltd., Wiring & Connectors Division, Cheney Manor, Swindon, Wilts.

For further information circle 49 on Service Card

Siemens & Halske Test Gear. R. H. Cole announce the availability of a range of leaflets which describe Siemens & Halske test gear. These include leaflets on Noise Intermodulation Measuring Setup, Complex-Ratio Tracing Receiver, Level Tracer, and Carrier-Frequency Measuring Setup.
R. H. Cole (Overseas) Ltd., 26-32 Caxton Street, London, S.W.1.

For further information circle 50 on Service Card

Mullard Special Quality Valves and Equivalents. A 6-page quick reference chart which gives abridged data for Mullard Special Quality Valves and equivalents of C.V., American, and standard types.
Mullard Ltd., Mullard House, Torrington Place, London, W.C.2.

For further information circle 51 on Service Card

T.M.C. Sound-Powered Telephones. In this 8-page brochure the complete range of T.M.C. sound-powered telephones and ancillary equipment is described. The equipment is designed for marine, mining, railway, factory building site and similar applications.
Telephone Manufacturing Co., Hubbard Road, London, S.E.27.

For further information circle 52 on Service Card

Kent Commander Range. An 11-page brochure which includes details of the recorders, indicators, integrators, controllers, transmitters and receivers in the Commander range. These are designed as accurate, easy-to-use instruments for process measurement and control.
George Kent Ltd., Luton, Beds.

For further information circle 53 on Service Card

Wayne Kerr Measuring Instruments. This 20-page brochure includes illustrations and brief specifications of the range of precision measuring instruments which are available from *Wayne Kerr Laboratories Ltd., New Malden, Surrey.*

For further information circle 54 on Service Card

Pulse Equipment Bulletin. This 6-page brochure gives details of the pulse, sweep, and time-delay generators, pulse amplifiers, and variable delay lines which are produced by the
General Radio Co., West Concord, Mass., U.S.A.

For further information circle 55 on Service Card

Sleeving and Tubing in Fluorocarbon TFE and FEP. In this 9-page booklet a list of the full range of Polypenco sleeving is given along with dimensions and tolerances.
Polypenco Ltd., Gate House, Welwyn Garden City, Herts.

For further information circle 56 on Service Card

Morganite Qualification Approved Components. Listed in this 11-page booklet are the ranges of Morganite variable resistors which are manufactured to the specification D.E.F.5122 and fixed resistors manufactured to D.E.F.5112; also some details are given for each type.
Morganite Resistors Ltd., Bede Trading Estate, Jarrow, Co. Durham.

For further information circle 57 on Service Card

Pye Scientific Instruments Catalogue. A 32-page booklet which gives comprehensive details of the current range of W. G. Pye instruments including chemical, d.c. electrical measuring, electronic and metrological instruments.
W. G. Pye & Co. Ltd., York Street, Cambridge.

For further information circle 58 on Service Card

English Numbering Machines Catalogue. This 60-page booklet gives details of the counting and numbering devices which are manufactured by:
English Numbering Machines Ltd., 25 Queensway, Enfield, Middlesex.

For further information circle 59 on Service Card

Ferranti Apollo Computer. This is an 18-page technical description of the Apollo computer.
Ferranti Ltd., 68 Newman Street, London, W.1.

For further information circle 60 on Service Card

A.E.I. Industrial Valves and Cathode Ray Tubes. A 47-page publication by:
Telecommunications Division of Associated Electrical Industries Ltd., 155 Charing Cross Road, London, W.C.2.

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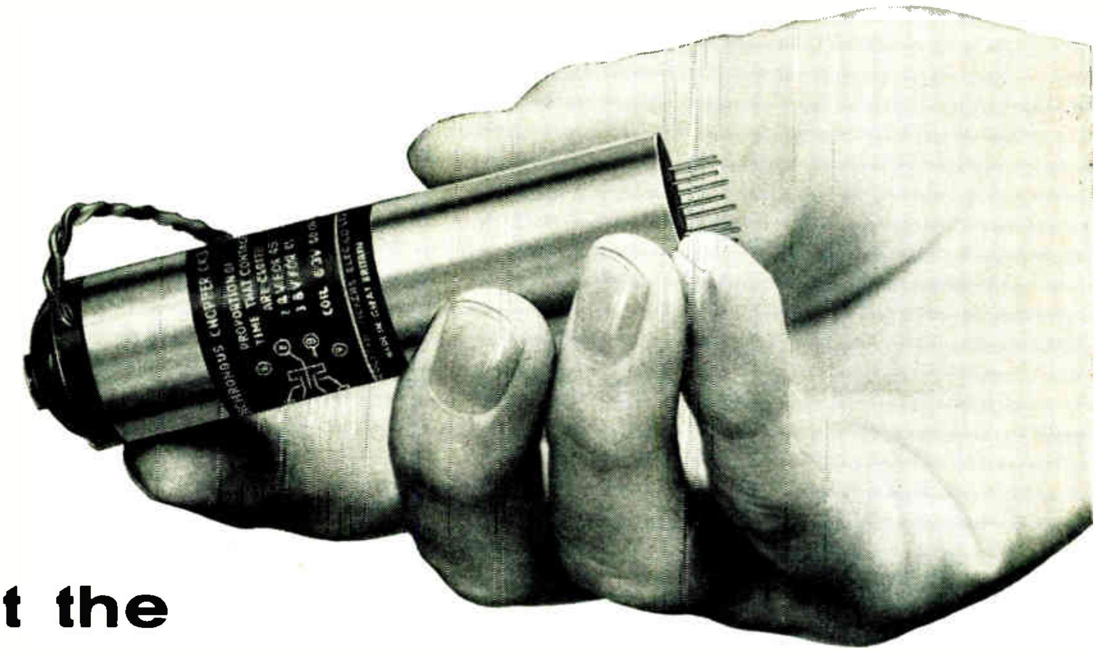

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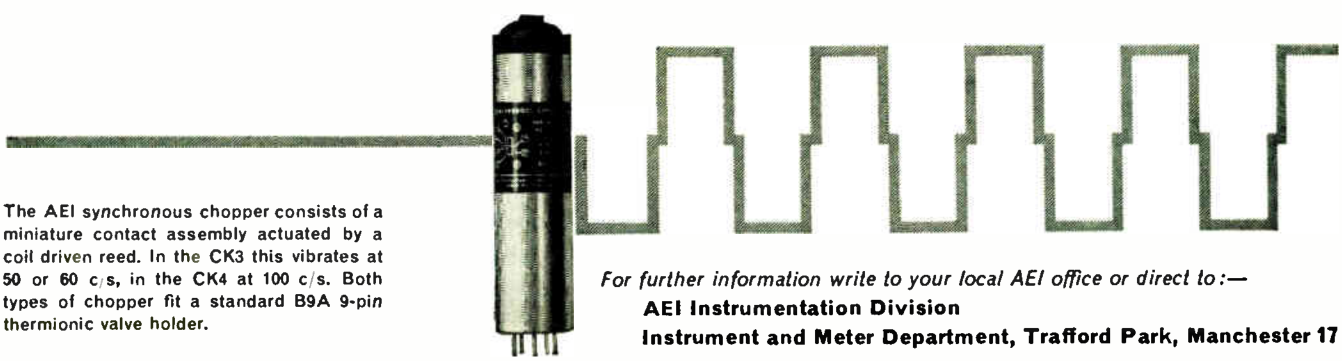

The AEI synchronous chopper consists of a miniature contact assembly actuated by a coil driven reed. In the CK3 this vibrates at 50 or 60 c/s, in the CK4 at 100 c/s. Both types of chopper fit a standard B9A 9-pin thermionic valve holder.

For further information write to your local AEI office or direct to:—
AEI Instrumentation Division
Instrument and Meter Department, Trafford Park, Manchester 17

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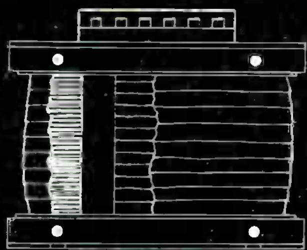
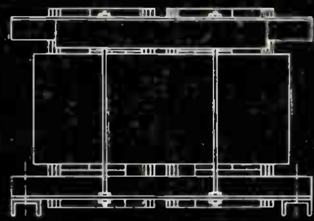
CORREACTOR



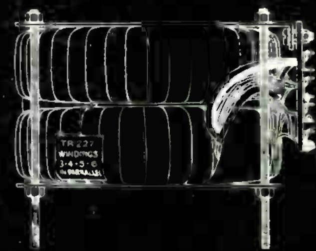
Designed for situations where high percentage regulation is not necessary, the **CORREACTOR** is Phoenix's answer to demand for a general purpose heavy duty component at an economical price. Percentage regulation is between 10% and 85%, load ranges from 125 W to 7 kW single phase.

CORREX
A.C.R.



Like the Correactor, the **A.C.R.** comprises three coils about a shellform core of laminated silicon iron. It has been designed for situations where wider output control range is required and higher power is to be used. Percentage regulation is between 10% and 93%, load ranges from 8 kW to 60 kW single phase.

CORREX
TOROIDAL REACTOR



TOROIDAL REACTORS are offered specifically for precision installations where higher power gains are called for. Power gains in the order of 10^5 are available with toroids. Toroidal Reactors can also be made to customers' own specifications. Maximum percentage regulation is 98% overall. Toroids are powered up to 60 kW single phase.

All these reactors are designed to operate on D.C. control, which can be varied by only small potentiometers in remote positions. Used in conjunction with CORREX Magnetic Amplifiers, they can be operated from signals on standard equipment down to 8μA. There are no moving parts, so no maintenance is needed.

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Five components, in the **M.A.420/430** range, are auto-excited single-ended stages of toroidal construction. They are used as driver stages for Saturable Reactors through variable D.C. output control. Voltage is set by bias control from a small transformer and selenium bridge rectifier.

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Newest among these Magnetic Amplifiers is the versatile **M.A.437**, driving a Post Office type 3000 relay at close differential. This is intended to trigger a function on a variable monitored control signal and also from signals too small to drive a conventional relay. Minimum operational signal for the M.A.437 is 80μA.

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34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51
52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69
70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87

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214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231
232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249
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16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51
52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69
70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87

Advertisement code number—				200	201	202	203	204	205	206	207	208	209	210	211	212	213
214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231
232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249
250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267

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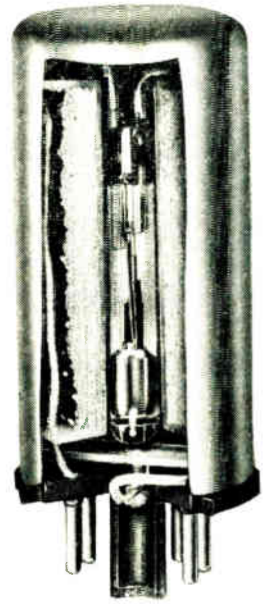

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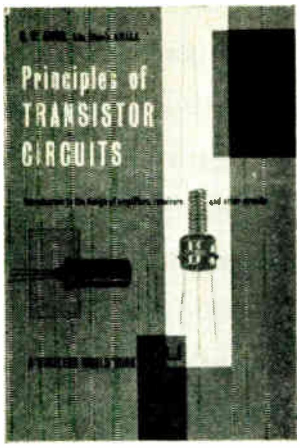

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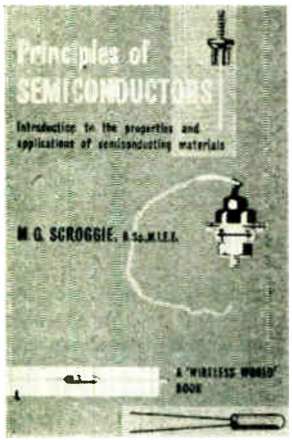

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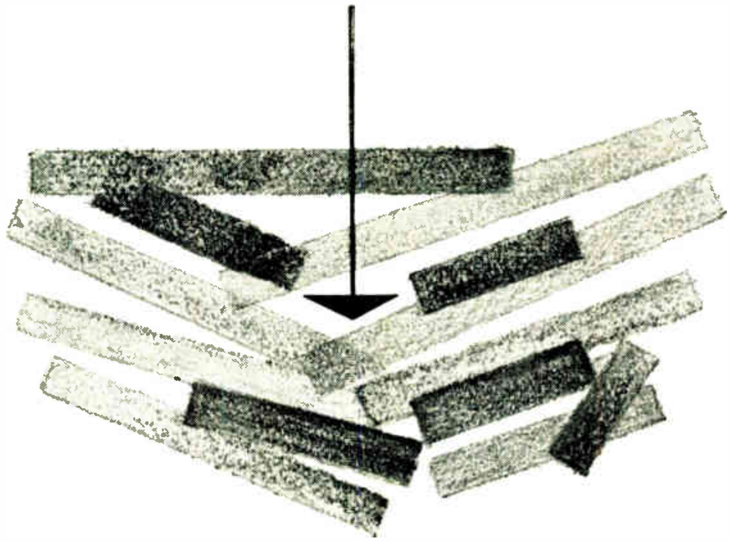

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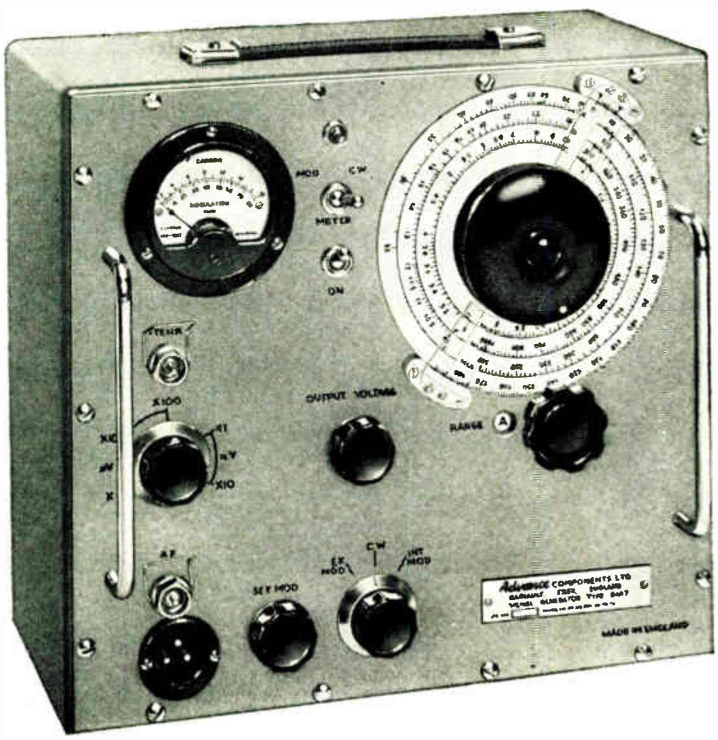

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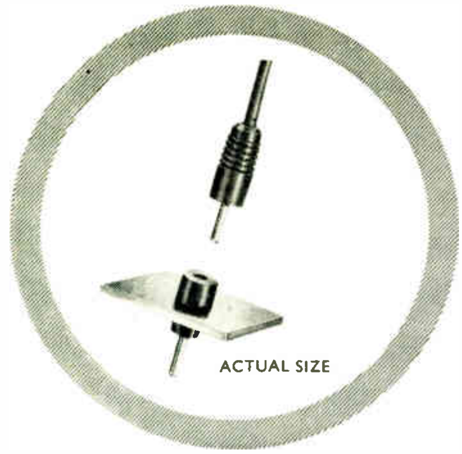

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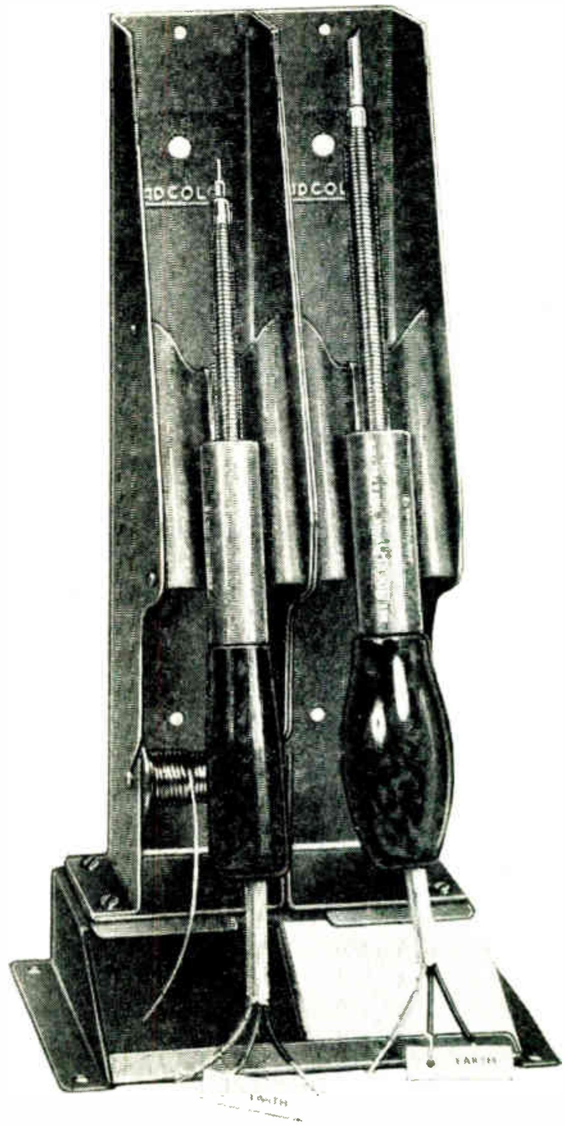

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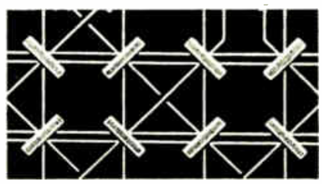

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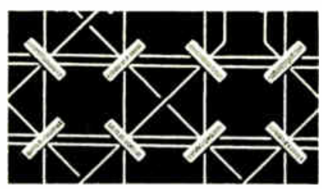

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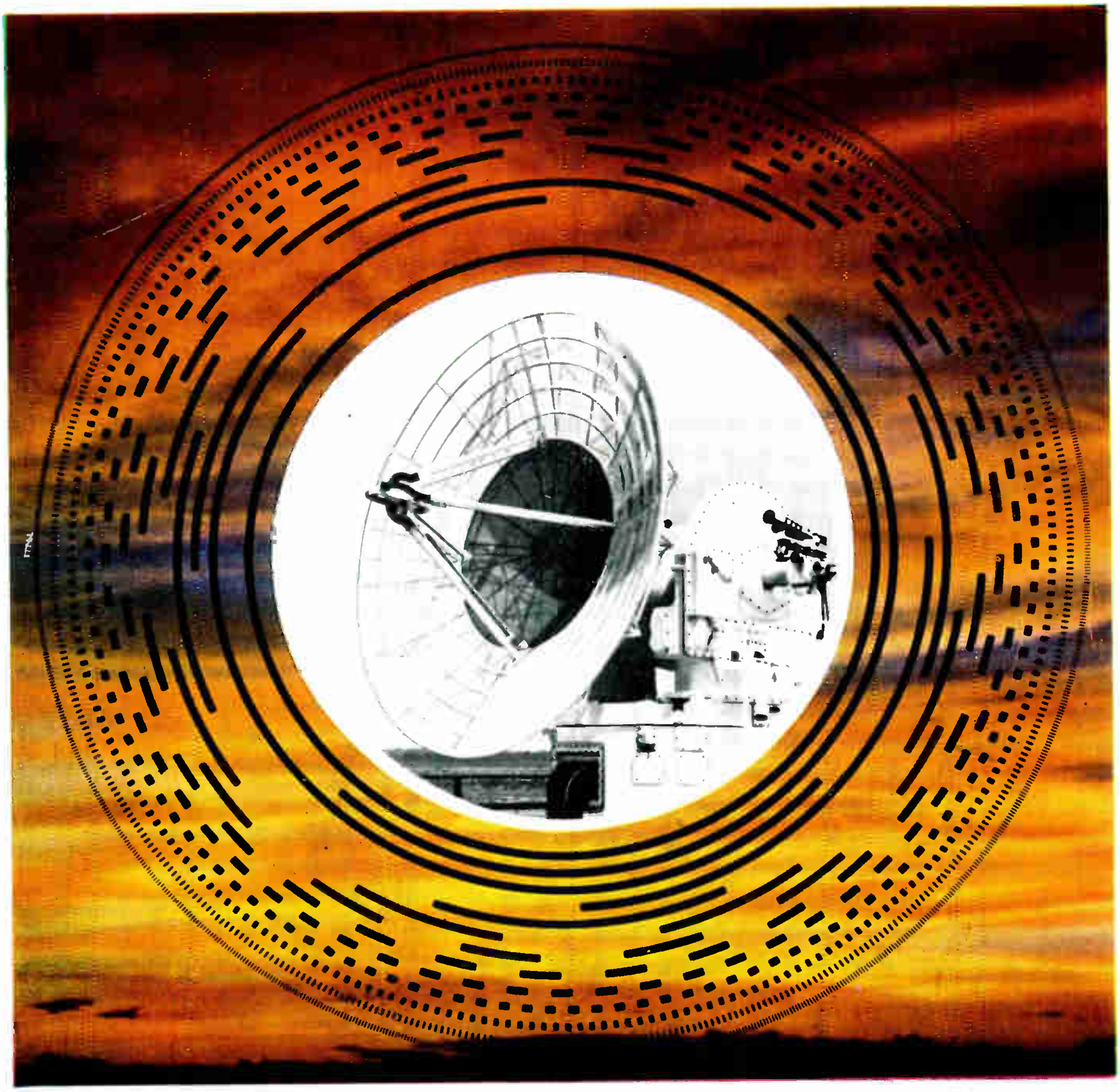

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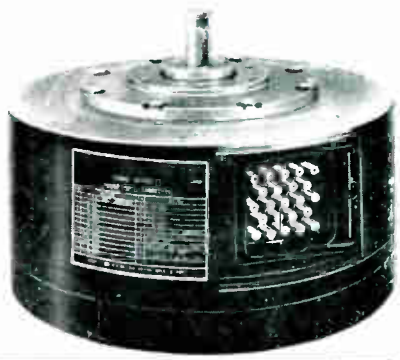

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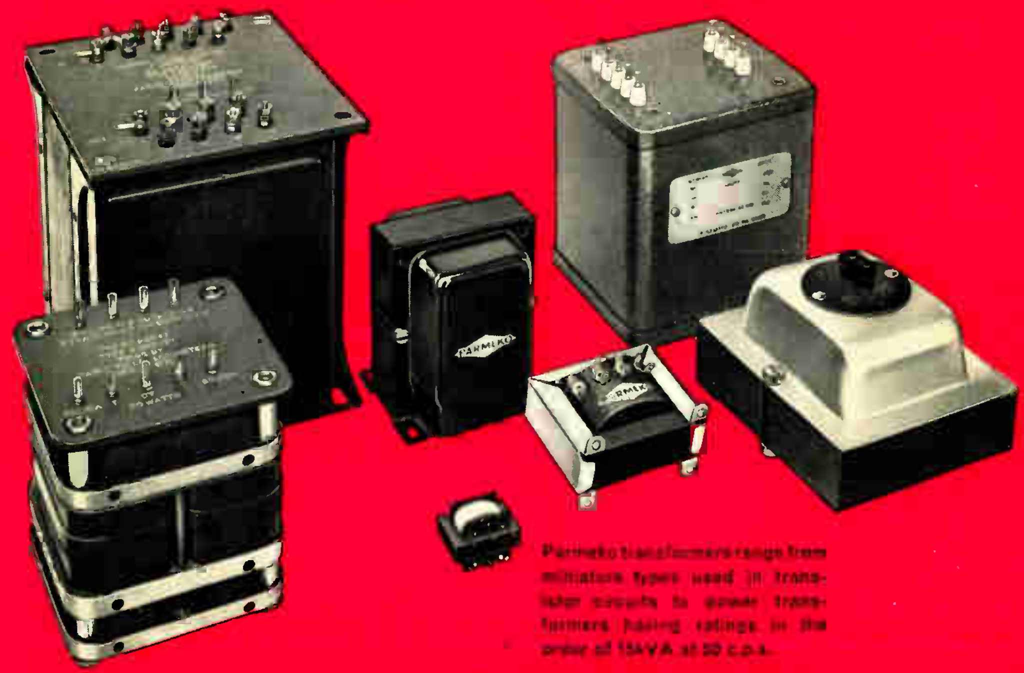

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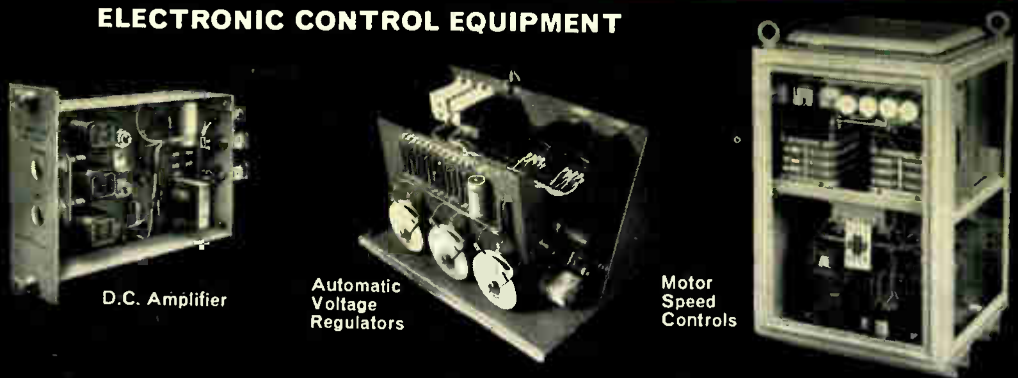

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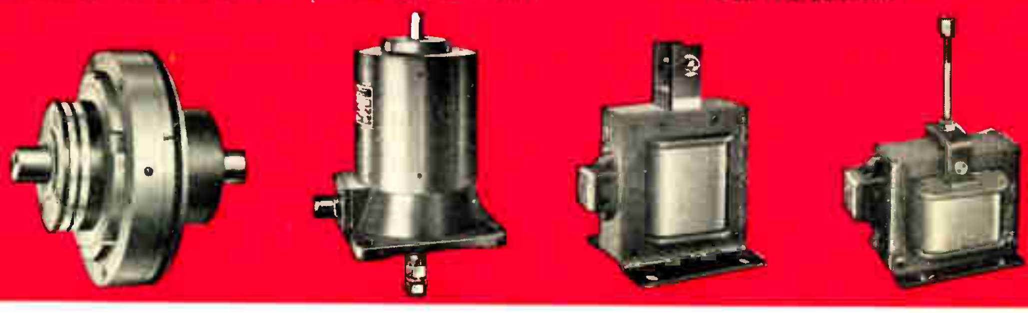

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