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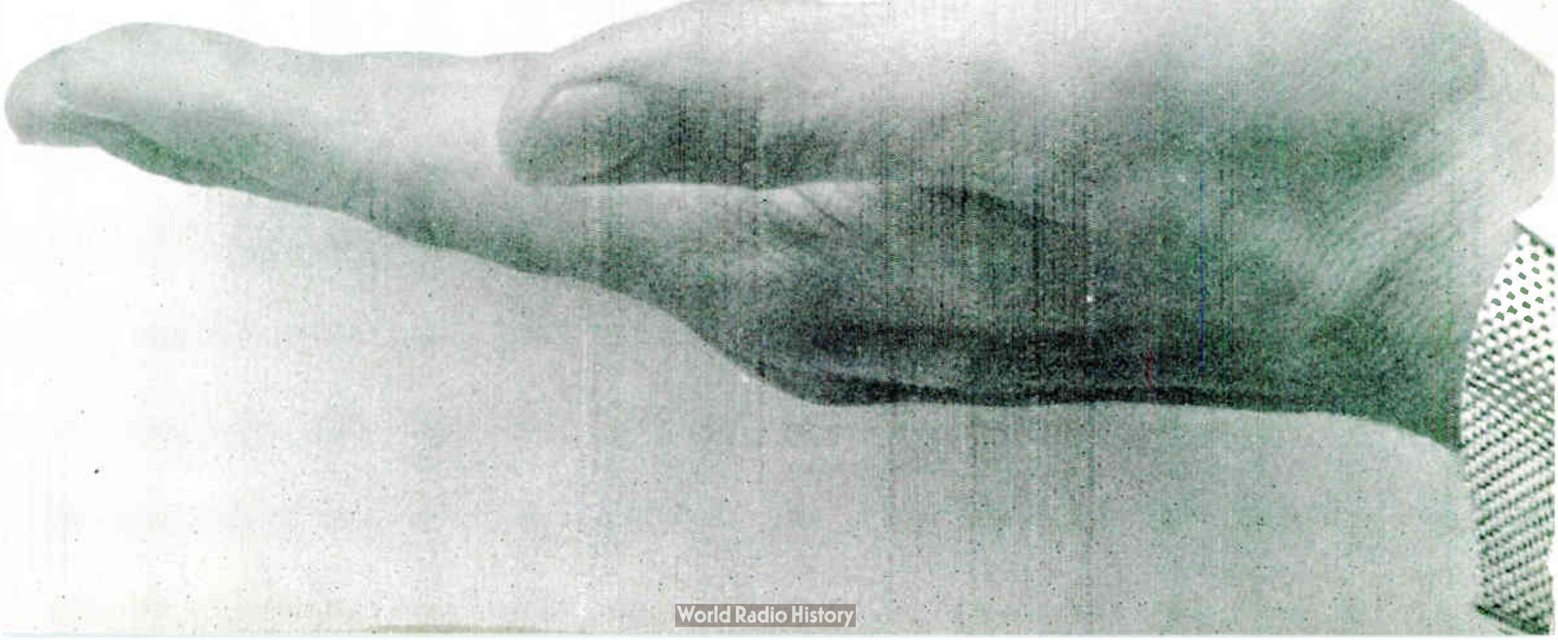

Abstracts and References

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

534:061.3 3910

Fourth International Congress on Acoustics.—(*Wireless World*, Oct. 1962, Vol. 68, No. 10, pp. 492–495.) A summary of some of the 350 papers presented at the Congress in Copenhagen, 21st–28th August 1962.

534.133 3911

Forced Vibrations of Piezoelectric Crystal Plates.—H. F. Tiersten & R. D. Mindlin. (*Quart. appl. Math.*, July 1962, Vol. 20, No. 2, pp. 107–119.) An extension is made to a previous paper by Mindlin (*ibid.*, April 1961, Vol. 19, No. 1, pp. 51–61) to include the piezoelectric relations and the electric field equations.

534.2-14 3912

Frequency Dependence of Acoustic Fluctuations in a Randomly Inhomogeneous Medium.—E. O. LaCasce, Jr, R. G. Stone & D. Mintzer. (*J. appl. Phys.*, Sept. 1962, Vol. 33, No. 9, pp. 2710–2714.) Experimental investigation of the propagation of a series of uniform acoustic pulses through water in which there are random time and space variations of temperature. The results are of interest with regard to e.m. wave propagation in inhomogeneous media.

534.2-14 3913

Experimental Investigation of the Acoustic Field in One Instance of Antiwaveguide Sound Propagation.—A. N. Barkhatov & S. P. Myasnikov. (*Akust. Zh.*, 1961, Vol. 7, No. 1, pp. 18–20.) Tank experiments are described to determine the field distribution in a laminar medium with a sound velocity maximum below the surface level of the liquid. A geometric shadow zone and other regions are defined in terms of their attenuation characteristic.

534.213.4 3914

On Sound Propagation in a Waveguide with Side Branches on the Walls.—A. D. Lapin. (*Akust. Zh.*, 1961, Vol. 7, No. 1, pp. 97–99.) A generalization of previous theory (1700 of 1961).

534.232 3915

The Electroacoustic Sensitivity of Cylindrical Ceramic Tubes.—C. P. Germano. (*J. acoust. Soc. Amer.*, Aug. 1962, Vol. 34, No. 8, pp. 1139–1141.) A supplement to the set of design charts given by Langevin (2830 of 1954) covering two of the $PbTiO_3$–$PbZrO_3$ ceramic compositions PZT-4 and PZT-5.

534.232:534.26 3916

Experimental Investigation of an Endfire Array.—J. L. S. Bellin & R. T. Beyer. (*J. acoust. Soc. Amer.*, Aug. 1962, Vol. 34, No. 8, pp. 1051–1054.) Pressure measurements of the scattering of two finite-amplitude collinear sound beams were made at 13·5 Mc/s in water and 350 kc/s in air. The slope of the curve of half-pressure angle versus difference frequency agrees well with theory.

534.232-8 3917

Investigation of the Field Structure of a Cylindrical Ultrasonic Concentrator.—I. N. Kanevskii. (*Akust. Zh.*, 1961, Vol. 7, No. 1, pp. 40–46.) An expression is derived for the potential of an infinitely converging cylindrical wave front and is used to calculate the distribution of potential and equiphase lines in the focal region. The effect of the height of a radiator on the axial field is considered. Experimental results are noted.

534.6 3918

Determination of the Energy Reflection, Absorption, and Transmission Coefficients of Acoustical Materials.—R. S. Caddy & H. F. Pollard. (*J. acoust. Soc. Amer.*, Aug. 1962, Vol. 34, No. 8, pp. 1138–1139.) The coefficients considered are applicable to any mounting conditions.

534.6-8:621.385.83:537.228.1 3919

Some Aspects of the Operation of an Electronic Acoustic Converter (E.A.C.).—Yu. B. Semennikov. (*Akust. Zh.*, 1961, Vol. 7, No. 1, pp. 73–77.) The load impedance and high-frequency operating characteristics of an ultrasonic image converter are discussed. Optimum electromechanical properties are obtained with $BaTiO_3$ or Y-cut $LiSO_4$ as piezoelectric material.

534.845 3920

Theory for Correlating Attenuation Data for Cylindrical Passages.—F. V. H. Judd. (*J. acoust. Soc. Amer.*, Aug. 1962, Vol. 34, No. 8, p. 1139.) A logarithmic theory has been developed giving good correlation with test data.

621.395.61:537.56 3921

A Wide-Band Oscillating-Velocity Microphone.—B. S. Zalivadnyi. (*Akust.*

Zh., 1961, Vol. 7, No. 1, pp. 94–96.) A pickup is described in which a sound wave passing through an ion cloud in the region of a collector grid produces a variation in the ion current flowing to the grid. A variable potential, proportional to the particle velocity in the sound field, is developed across a resistor in the input circuit of a valve amplifier.

AERIALS AND TRANSMISSION LINES

621.372.2 **3922**

Propagation of Microwaves on a Single Wire: Part 4.—V. Subrahmanyam. (*J. Indian Inst. Sci.*, July 1962, Vol. 44, No. 3, pp. 122–140.) A theoretical study of the reduction of phase velocity and radial field spread of the Harms-Goubau line, as a function of wire radius, coating thickness and dielectric constant. Part 3: 1806 of June.

621.372.823: 621.317.74 **3923**

Measurements on Circular Electric Waveguide Characteristics by the Resonant-Cavity Method.—Shimba. (See 4170.)

621.372.823: 621.372.853.1 **3924**

Imperfections in Lined Waveguide.—H. L. Kreipe & H. G. Unger. (*Bell Syst. tech. J.*, Sept. 1962, Vol. 41, No. 5, pp. 1589–1619.) Generalized telegraphist's equations are derived for an imperfect lining in a circular waveguide and also for a waveguide with deformed cross-section.

621.372.832: 621.385.6 **3925**

Heating of Waveguide Windows as a Limit to the Output Power of Microwave Tubes.—F. Paschke. (*RCA Rev.*, Sept. 1962, Vol. 23, No. 3, pp. 311–322.) The maximum power which can be transmitted through a strip-line window is calculated and the influence of window bombardment and material defects is evaluated.

621.372.832.4: 621.317.34 **3926**

Novel Slotted Line uses Slow-Wave Technique.—L. L. Oh & C. D. Landen. (*Electronics*, 31st Aug. 1962, Vol. 35, No. 35, pp. 46–47.) A line 3–5 ft long will measure voltage s.w.r. and impedance from 25 to about 200 Mc/s. A tunable probe (25–1 000 Mc/s) is used in which lumped or semi-distributed *LC* circuits replace the stubs used in a conventional double-stub tuner. Three 50-Ω lines are described.

621.372.832.43 **3927**

Design of Tchebycheff Directional Couplers with Weak Coupling.—A. L. Fel'dshtein & E. S. Zhavoronkova. (*Radiotekhnika, Mosk.*, Jan. 1962, Vol. 17, No. 1, pp. 40–50.) A systematic design procedure for multielement couplers is described and design data for units comprising from two to eleven elements are tabulated.

621.372.837.3: 621.376.22 **3928**

Calculation of the Optimum Parameters of Ferrite Systems based on the Faraday Effect.—A. M. Starodubtsev. (*Radiotekhnika, Mosk.*, Jan. 1962, Vol. 17, No. 1, pp. 32–39.) The operation of a Faraday-effect device is analysed in terms of an eight-terminal network. The results are applied to determine (*a*) the influence of load reflection coefficients in a ferrite isolator and (*b*) the effects of space and time asymmetry on the operation of a ferrite modulator under rectangular-wave and sine-wave conditions.

621.372.852.21 **3929**

Some Electrodynamic Characteristics of a Rectangular Waveguide Loaded with Dielectric Diaphragms.—L. N. Beznaternykh. (*Radiotekhnika i Elektronika*, June 1962, Vol. 7, No. 6, pp. 995–1001.) A general expression for the field components is derived and a dispersion equation for the co-phased waves of the system is considered.

621.396.67: 621.391.8 **3930**

On the Reception of Quasi-Monochromatic, Partially Polarized Radio Waves.—H. C. Ko. (*Proc. Inst. Radio Engrs*, Sept. 1962, Vol. 50, No. 9, pp. 1950–1957.) The response of an elliptically polarized aerial to a partially polarized wave is treated from the standpoint of coherence theory. Conditions for maximum available power are discussed and a new definition for aerial effective aperture is suggested.

621.396.67.029.45: 629.132.1 **3931**

Balloon-Supported Aerials for Use at V.L.F.—R. N. Gould, W. R. Carter & A. T. Rawles. (*Wireless World*, Oct. 1962, Vol. 68, No. 10, pp. 502–506.) The theory is considered and results of experimental trials with a balloon supporting an aerial at a height of 4 200 ft are tabulated.

621.396.674.3 **3932**

The Analytical Extension of Aerial Impedances $Z(\nu + j\omega)$ from the Imaginary Axis into the Positive Half-Plane $\nu > 0$.—K. Fränz & A. Riedl. (*Z. Phys.*, 30th July 1962, Vol. 169, No. 1, pp. 72–78.) The variational principle used gives the lower limits for $Z(\nu)$ instead of the upper ones obtained in 1731 of 1961 (Fränz). A proof is derived for a formula relating the impedance of a free radiating dipole to the impedance of the same dipole when enclosed in a distant reflecting shell.

621.396.674.3 **3933**

Getting Maximum Bandwidth with Dipole Antennas.—H. Shnitkin & S. Levy. (*Electronics*, 31st Aug. 1962, Vol. 35, No. 35, pp. 40–42.) Design equations are derived from a zero-pole analysis to determine the maximum bandwidth for a given maximum voltage s.w.r. In an example quoted a s.w.r. of 1·2–1·5 is achieved in the frequency range 350–600 Mc/s.

621.396.674.3 **3934**

Dielectric Loading of Electric Dipole Antennas.—J. Galejs. (*J. Res. nat. Bur. Stand.*, Sept./Oct. 1962, Vol. 66D, No. 5, pp. 557–562.) The small dipole and the small-angle biconical aerial show a different variation with dielectric loading than the wide-angle biconical aerial and the capacitor-type aerial [1261 of 1948 (Wheeler)].

621.396.674.3: 551.510.535 **3935**

Possible Influence of the Ionosphere on the Impedance of a Ground-Based Antenna.—J. R. Wait. (*J. Res. nat. Bur. Stand.*, Sept./Oct. 1962, Vol. 66D, No. 5, pp. 563–569.) An analysis is given for the impedance of a vertical electric dipole in the presence of an isotropic and homogeneous conducting half-space. The presence of an ionosphere has a negligible effect on aerial impedance for frequencies > 1 kc/s.

621.396.677: 621.396.946 **3936**

Modern Antennas in Space Communications.—C. J. Sletten. (*Electronics*, 7th Sept. 1962, Vol. 35, No. 36, pp. 39–48.) A comprehensive review of aerial design techniques developed to meet the requirements of greater resolving power, higher gain, and improved scanning ability.

621.396.677.3 **3937**

Theory of Non-equidistant Linear Aerials.—E. V. Baklanov, V. L. Pokrovskii & G. I. Surdutovich. (*Radiotekhnika i Elektronika*, June 1962, Vol. 7, No. 6, pp. 963–972.) Analysis of the radiation diagrams of multi-element arrays.

621.396.677.3: 523.164 **3938**

Method of Phasing the Elements of an Aerial Array.—É. J. Blum, J. Delannoy & M. Joshi. (*C. R. Acad. Sci., Paris*, 24th April 1961, Vol. 252, No. 17, pp. 2517–2519.) The method described [see 3469 of 1960 (Malinge et al.)] was used for setting up the radiotelescope at Nançay. An accuracy within 1 part in 10^4 is attained using a minimum number of observations.

621.396.677.71 **3939**

Currents Induced on the Surface of a Conducting Circular Cylinder by a Slot.—G. Hasserjian & A. Ishimaru. (*J. Res. nat. Bur. Stand.*, May/June 1962, Vol. 66D, No. 3, pp. 335–365.) Mathematical treatment of cylinders of small and large radius with narrow longitudinal and circumferential slots.

621.396.677.75 **3940**

Electromagnetic Waves on a Semi-infinite Conically Tapered Circular Dielectric Rod.—A. Kumar & R. Chatterjee. (*J. Instn Telecommun. Engrs, India*, July 1962, Vol. 8, No. 4, pp. 171–178.) The field distribution is found to comprise only the circularly symmetric electric modes.

621.396.677.83 **3941**

Double-Mirror Aerials.—B. E. Kinber. (*Radiotekhnika i Elektronika*, June 1962, Vol. 7, No. 6, pp. 973–980.) An axisymmetric arrangement of two mirrors is described whereby the radiation from a normal exciter is transformed after two reflections into a plane wave of constant amplitude.

621.396.677.85 **3942**

The Geodesic Luneberg Lens.—R. C. Johnson. (*Microwave J.*, Aug. 1962, Vol. 5, No. 8, pp. 76–85.) Different geodesic lenses, including a scanning type, and the design procedure are described.

621.396.677.85 **3943**

Radiation Pattern of Beam-Scanning Aerials.—N. G. Ponomarev. (*Radiotekhnika i Elektronika*, June 1962, Vol. 7, No. 6, pp. 949–962.) An analysis of the directivity of electronically scanned arrays. The instantaneous and static radiation diagrams are shown to differ. The limiting scanning frequency for coincidence is calculated.

AUTOMATIC COMPUTERS

681.142 **3944**

New Approach to Serial Decoding Eliminates Static Storage.—R. M. Centner & J. R. Wilkinson. (*Electronics*, 24th Aug. 1962, Vol. 35, No. 34, pp. 32–35.) "Linear summation of charges placed on a capacitor by successive pulses of a binary number yields a voltage proportional to that number."

681.142 **3945**

Multiplication of Electrical Signals by means of a Three-Electrode Hall E.M.F. Generator.—M. E. Mazurov & I. N. Prudnikov. (*Izv. Ak. Nauk S.S.S.R. otd. tekh. nauk, Energetika i Avtomatika*, March/April 1962, No. 2, pp. 148–155.) Design details and performance data are given for an InSb Hall-effect multiplier.

681.142 : 537.312.62 **3946**

A Proposal for a Fast Random-Access Computer Store based on the Superconducting Device known as the Crowe Cell.—J. M. Lock, D. H. Parkinson & L. M. Roberts. (*Solid-State Electronics*, Sept. Oct. 1962, Vol. 5, pp. 301–311.) A design for a high-speed store of up to 10^7 Crowe cells evaporated in rectangular arrays which are stacked in a 35-cm cube is proposed. Switching times of 10–15 ns are expected.

681.142 : 621.318.042.1 **3947**

Reversible Flux as a Source of Irreversible Noise in Multipath Cores.—J. A. Baldwin, Jr. (*J. appl. Phys.*, May 1962, Vol. 33, No. 5, pp. 1654–1659.)

681.142 : 621.318.57 : 621.382.23 **3948**

The Cryosar: Promising Element for Tomorrow's Computers.—L. M. Lambert & J. E. McAteer. (*Electronics*, 17th Aug. 1962, Vol. 35, No. 33, pp. 39–45.) Advantages of the device [see 3211 of 1959 (McWhorter & Rediker)] are low element cost, low power dissipation and simplicity of construction. Storage system, logic and pulse-generator applications are described. See also 3658 of 1961 (Izumi).

681.142 : 621.382.3 **3949**

Novel Design Technique for Transistor Digital Circuits.—R. W. Hockenberger. (*Electronics*, 24th Aug. 1962, Vol. 35, No. 34, pp. 42–46.) Deviations in performance due to parameter variations are shown graphically. Component values are determined with reference to graphs plotted from the equivalent circuit for (*a*) cut-off, and (*b*) saturation conditions.

CIRCUITS AND CIRCUIT ELEMENTS

621.3.049.75 **3950**

How to Design Micromodules.—R. DiStefano, Jr. (*Electronics*, 14th Sept. 1962, Vol. 35, No. 37, pp. 37–41.) General survey of current procedures.

621.3.049.75 : 539.23 **3951**

Sputtered Components in Thin-Film Circuits.—P. Lloyd. (*Industr. Electronics*, Oct. 1962, Vol. 1, No. 1, pp. 22–24.) "Experimental work on producing resistors and capacitors by thin films of sputtered material is described. A demonstration multivibrator made by the technique illustrates its capabilities."

621.3.049.75 : 621.382 **3952**

Proposed Formation of Micro-integrated Circuits.—H. Osafune & I. Sasaki. (*NEC Res. Developm.*, June 1962, No. 3, pp. 37–45.) Using alloy diffusion techniques four different *p-n* junctions are fabricated simultaneously with only one heat treatment. The characteristics and applications of a subcircuit incorporating *p-n-p-n* and *p-n-p* junctions are described.

621.314.2 **3953**

Wide-Band Transformers and Associated Coupling Networks.—T. R. O'Meara. (*Electro-Technol.*, Sept. 1962, Vol. 70, No. 3, pp. 80–89.) Performance criteria and design data for transformers with bandwidths of a decade or more are given together with the related network characteristics. The 37 references listed cover other aspects of design, such as core heating, mid-band insertion loss and voltage stress.

621.316.86 : 621.391.822 **3954**

The Physical Meaning of Formulae for Excess Noise in Composition Resistors.—T. S. Korn, J. D'Hooghe & J. M. Kleinplac. (*J. Brit. Instn Radio Engrs*, Sept. 1962, Vol. 24, No. 3, pp. 221–222.) An extension of work by Hettich (1601 of 1950) to generalize his formula for excess current noise in resistors leads to a physical interpretation of Bernamont's formula (*Ann. Phys., Paris*, 1937, Vol. 7, p. 71).

621.318.57 : 621.372.837 **3955**

Five New Diode Circuits for Nanosecond Microwave Switching. P. Ravenhill & H. Smith. (*Electronics*, 31st Aug. 1962, Vol. 35, No. 35, pp. 37–39.) Powers of 2–5 W and less can be handled; bandwidths must be less than 5% of centre frequency.

621.318.57 : 621.382.23 **3956**

The Effect of Mutual Inductance upon Tunnel-Diode Locked-Pair Switching.—A. C. Scott, W. J. Dunnet & R. W. Taylor. (*Proc. Inst. Radio Engrs*, Sept. 1962, Vol. 50, No. 9, pp. 1991–1992.) Significant improvement in high-speed switching can be achieved by the addition of mutual coupling between the loops of the two diodes.

621.372.012 : 621.375.4 **3957**

On Calculating the Parameters of a Quadripole by the Method of Null-Node Graphs.—Y. Chow & É. Cassignol. (*C. R. Acad. Sci., Paris*, 13th March 1961, Vol. 252, No. 11, pp. 1574–1576.) A method of analysing a quadripole using signal flow graphs (see 402 of February) is developed and applied to a transistor amplifier with series negative feedback.

621.372.413 : 621.385.64 **3958**

The Natural Frequencies of Capacitively Loaded Cavity Resonators of the Interdigital Type.—H. Paul. (*Frequenz*, July & Aug. 1962, Vol. 16, Nos. 7 & 8, pp. 271–278 & 308–314.) Expressions and diagrams are given for determining the resonance frequencies of magnetron cavities oscillating in the E_{01}, E_{11} and E_{21} mode.

621.372.44 **3959**

The Dynamic Behaviour of Negative-Resistance Devices.—C. O. Harbourt. (*Commun. & Electronics*, July 1962, No. 61, pp. 216–222.) The results obtained by analogue computer simulation are shown to be descriptive of the behaviour of actual tunnel-diode circuits.

621.372.5 **3960**

A New Class of Distributed *RC* Ladder Networks.—M. J. Hellstrom. (*Proc. Inst. Radio Engrs*, Sept. 1962, Vol. 50, No. 9, pp. 1989–1990.)

621.372.5 : 534.143 **3961**

A Piezoelectric-Piezomagnetic Gyrator.—M. Onoe & M. Sawabe. (*Proc. Inst. Radio Engrs*, Sept. 1962, Vol. 50, No. 9, pp. 1967–1973.) A new type of electromechanical 'achromatic' isolator is described. It consists of three mechanically coupled transducers, two of which may be piezoelectric and one piezomagnetic, or two piezomagnetic and one piezoelectric. Equivalent circuits are derived and the characteristics of an experimental isolator operating at 135 kc/s are given.

621.372.54 **3962**

Simplified Low-Pass Filter Design.—W. J. Kerwin. (*Electronics*, 7th Sept. 1962, Vol. 35, No. 36, pp. 52–53.) A new design method enabling the point of infinite rejection to be directly chosen.

621.372.54 **3963**

A Filter for Exponential Signals.—A. Pozwolski. (*Onde élect.*, July/Aug. 1962, Vol. 42, Nos. 424–425, pp. 636–637.) A circuit arrangement is suggested for suppressing the noise components of an exponential signal and reducing it to the form Ae^{at} where A is a constant.

621.372.54 : 621.318.57 **3964**

A Variable-Parameter Direct-Current Switching Filter.—G. F. Montgomery. (*Proc. Inst. Radio Engrs*, Sept. 1962, Vol. 50, No. 9, p. 1986.) The filter discussed is intended for envelope shaping in a radiotelegraphy transmitter, and eliminates contact dissipation by means of a rectifier which varies the network structure.

621.372.54 : 621.375.4 **3965**

On the Approximation Problem for Band-Pass Delay Lines.—P. R. Geffe.

(*Proc. Inst. Radio Engrs*, Sept. 1962, Vol. 50, No. 9, pp. 1986–1987.) A transformation for use in band-pass network design is described with an example.

621.372.543 **3966**

Linear Band-Filter Circuits for High-Frequency Techniques.—E. Trzeba. (*NachrTech.*, June–Aug. 1962, Vol. 12, Nos. 6–8, pp. 202–206, 272–277 & 297–302.) General theoretical treatment with particular consideration of phase variations as a function of frequency.

621.372.6 **3967**

Flow Graph Determination of the Over-All Scattering Matrix of Joined Multiports.—M. R. Leibowitz. (*Proc. Inst. Radio Engrs*, Sept. 1962, Vol. 50, No. 9, p. 1982.) The synthesis of a given multiport from simpler interconnected multiports is described.

621.372.6: 621.382.23 **3968**

The Tunnel Diode as a Linear Network Element.—I. W. Sandberg. (*Bell Syst. tech. J.*, Sept. 1962, Vol. 41, No. 5, pp. 1537–1556.) "Theorems are proved which completely characterize in an explicit manner the class of immittance matrices realizable with lossless reciprocal elements and a tunnel diode represented by the three-parameter '*LC*, –*R*' model. Techniques are presented for the synthesis of any immittance matrix within this class."

621.373.431.1: 621.382.23 **3969**

Comparison of Tunnel-Diode Monostable Multivibrators.—M. J. Morgan. (*Semiconductor Prod.*, July 1962, Vol. 5, No. 7, pp. 9–15.) Rise time, pulse duration, fall and recovery times are discussed for the single-diode multivibrator, the voltage-biased diode pair and the current-biased diode pair.

621.373.444: 621.382.3 **3970**

New Complementary Transistors make Series Schmitt Circuits Practical.—J. K. Skilling. (*Electronics*, 31st Aug. 1962, Vol. 35, No. 35, pp. 52–53.) The two transistors are either both on or both off, thus conserving power in comparison with a parallel circuit when on/off ratios are low.

621.373.52 **3971**

Circuit with Tunnel Diode and Transistor.—E. Klein & E. Buder. (*Nachrichtentech. Z.*, July 1962, Vol. 15, No. 7, pp. 318–322.) A simple tunnel-diode/transistor combination is described which can be used as an oscillator or as a triggering device without a low-impedance voltage divider.

621.374: 621.382.3 **3972**

Semiconductor Modulators for Modern Magnetrons.—F. A. Gateka & M. L. Embree. (*Electronics*, 14th Sept. 1962, Vol. 35, No. 37, pp. 42–45.) A pulse modulator has been developed that delivers 300 kW at 16 Gc/s using *p-n-p-n* transistor switches.

621.374.4: 537.227 **3973**

Ferroelectric Harmonic Generator and the Large-Signal Microwave Characteristics of a Ferroelectric Ceramic.—M. DiDomenico, Jr, D. A. Johnson & R. H. Pantell. (*J. appl. Phys.*, May 1962, Vol. 33, No. 5, pp. 1697–1706.) A 3- to -9-Gc/s harmonic generator has been constructed based on the nonlinear characteristic of the ceramic $BaTiO_3$ (73%)–$SrTiO_3$ (27%).

621.374.4: 621.382.23 **3974**

A New Frequency Demultiplier with a Tunnel Diode.—M. Shimura. (*Proc. Inst. Radio Engrs*, Sept. 1962, Vol. 50, No. 9, p. 1987.) In the single-diode circuit described the tunnel diode functions as a negative resistance as well as a rectifier device.

621.374.5 **3975**

Delay Lines with Distributed Constants for Nanosecond Pulse Circuits.—V. A. Solov'ev. (*Radiotekhnika, Mosk.*, Jan. 1962, Vol. 17, No. 1, pp. 22–31.) Design formulae for distributed capacitance and pulse rise time of helical delay lines are given and the construction of a delay line comprising a multiconductor flat helix with twin return lines is described.

621.374.5: 538.652 **3976**

What is the Optimum Mode for Magnetostrictive Delay Lines?—A. Rothbart & A. J. Brown. (*Electronics*, 31st Aug. 1962, Vol. 35, No. 35, pp. 43–45.) Several return-to-zero (r.t.z.) and non-r.t.z. modes of operation are described.

621.375.13: 621.317.321.027.21 **3977**

Negative-Impedance Electrometer Amplifiers—Introduction.—E. F. MacNichol, Jr. (*Proc. Inst. Radio Engrs*, Sept. 1962, Vol. 50, No. 9, pp. 1909–1911.) A class of wide-band amplifiers is described in which a high input impedance is achieved by capacitance neutralization, and the design of an electrometer amplifier using a field-effect transistor is outlined.

621.375.13: 621.317.321.027.21 **3978**

Cathode Follower and Negative Capacitance as High-Input-Impedance Circuits.—C. Guld. (*Proc. Inst. Radio Engrs*, Sept. 1962, Vol. 50, No. 9, pp. 1912–1927.) An analysis is made of the operation of cathode-follower and negative-impedance devices for biological measurements. Their performance in respect of neutralization of input capacitance, noise and grid current is assessed.

621.375.13: 621.317.321.027.21 **3979**

Stabilized Wide-Band Potentiometric Preamplifiers.—J. W. Moore & J. H. Gebhart. (*Proc. Inst. Radio Engrs*, Sept. 1962, Vol. 50, No. 9, pp. 1928–1941.) Techniques for achieving low grid current, linearity, low drift and capacitance compensation in amplifiers for bioelectric measurements are considered. Some suitable circuits are described.

621.375.13: 621.317.321.027.21 **3980**

Bandwidth Limits for Neutralized-Input-Capacity Amplifiers.—R. L. Schoenfeld. (*Proc. Inst. Radio Engrs*, Sept. 1962, Vol. 50, No. 9, pp. 1942–1950.) Criteria for bandwidth limits are developed. Second-order amplifiers can achieve a faster response than single-time-constant devices.

621.375.4 **3981**

Problems concerning Transformerless Transistor Power Amplifiers.—G. B. Debiasi. (*Alta Frequenza*, May 1962, Vol. 31, No. 5, pp. 308–314. In English.) Translated version of 3689 of 1961.

621.375.9: 538.569.4 **3982**

Investigation of a Maser using Cross-Relaxation.—Y. Ayant, R. Buisson, D. Descamps & M. Soutif. (*C. R. Acad. Sci., Paris*, 15th April 1961, Vol. 252, No. 14, pp. 2081–2083.) The conditions unfavourable to population inversion in a multilevel maser are analysed and it is shown how they may be made favourable. The method is applied to a ruby maser operating in S band and its success confirmed by experiment.

621.375.9: 538.569.4: 621.372.632 **3983**

Heterodyne Properties of a Three-Level Quantum System.—W. H. Wells. (*J. appl. Phys.*, May 1962, Vol. 33, No. 5, pp. 1851–1861.) Detailed treatment of a three-level system in terms of a three-terminal-pair circuit element. With one terminal-pair receiving pump power, the properties of the other two pairs are examined at small signal levels.

621.375.9: 621.372.44 **3984**

Some Observations about Minimum Noise Temperature of Parametric Amplifiers.—G. B. Stracca. (*Alta Frequenza*, May 1962, Vol. 31, No. 5, pp. 315–316. In English.) The expression for the minimum noise temperature of three-frequency parametric amplifiers is discussed.

621.375.9: 621.372.44 **3985**

An Experimental Technique for Parametric Devices.—A. C. Hudson & E. J. Stevens. (*Proc. Inst. Radio Engrs.*, Sept. 1962, Vol. 50, No. 9, pp. 1992–1993.) A method facilitating any rapid alterations to an experimental parametric amplifier is described. The amplifier is completely coaxial and consists of a centre conductor and an array of brass washers of different internal diameter and thickness. The amplifier configuration can be modified by replacing washers with others of different dimensions. Performance figures are given.

621.375.9: 621.372.44 **3986**

Theoretical Analysis of Periodically Loaded Parametric Amplifier.—S. Hamada. (*Rev. elect. Commun. Lab., Japan*, May/June 1962, Vol. 10, Nos. 5/6, pp. 305–311.) An investigation of the internal reflections in the system shows that the unidirectional losses must be introduced along the periodic line if a wide flat frequency characteristic as well as a low noise figure are desired.

621.375.9: 621.372.44 **3987**

Is this the Simplest Paramp ever Built?—R. J. Mayer. (*Electronics*, 14th Sept. 1962, Vol. 35, No. 37, pp. 46–47.) A parametric amplifier for v.h.f. and lower microwave frequencies is described comprising one butterfly resonator and one varactor diode with coupling loops.

621.375.9: 621.372.44: 621.382.3 **3988**

Very-Low-Noise Transistor Amplifiers in the U.H.F. Band using the Para-

metric Conversion Mode.—U. L. Rohde. (*J. Brit. Instn Radio Engrs*, Sept. 1962, Vol. 24, No. 3, pp. 223–228.) A new method is described for achieving high conversion gain with extremely low noise in a u.h.f. amplifier using h.f. transistors instead of varactor diodes and isolators.

621.376.22: 621.382.23 **3989**

Suppressed-Carrier Modulation with Tunnel Diodes.—B. Rabinovici, J. Klapper & S. Kallus. (*Commun. & Electronics*, July 1962, No. 61, pp. 205–209.) A sideband/carrier ratio of 40 db is achieved with a single tunnel diode. A balanced modulator using two tunnel diodes acts as a ring modulator.

621.376.223 **3990**

Conversion Loss in Rectifier Modulators. D. P. Howson. (*Industr. Electronics*, Oct. & Nov. 1962, Vol. 1, Nos. 1 & 2, pp. 46–51 & 101–103.) The design characteristics of different types of modulator circuits are described and ways of minimizing the conversion-loss variations by feedback are considered.

GENERAL PHYSICS

530.112: 530.12 **3991**

A Proposed First-Order Relativity Test using Lasers.—C. W. Carnahan. (*Proc. Inst. Radio Engrs*, Sept. 1962, Vol. 50, No. 9, p. 1976.) A test for ether drift, with an accuracy potentially greater than that of the Michelson-Morley experiment, is proposed.

537.291 + 538.691 **3992**

The Movements of Charge Carriers in Gases with Pulsating Magnetic Fields.—W. O. Schumann. (*Z. angew. Phys.*, Aug. 1962, Vol. 14, No. 8, pp. 512–516.) Continuation of the investigations described in 781 of March.

537.311.33 **3993**

Collective Excitation of Degenerate Plasmas in Solids.—M. J. Harrison. (*J. Phys. Chem. Solids*, Aug. 1962, Vol. 23, pp. 1079–1086.) A current-carrying two-component plasma is studied, using Boltzmann's equation and the self-consistent field approximation. Unstable oscillations of acoustic type and stable high-frequency oscillations can occur.

537.56 **3994**

Shock Waves in Plasma.—P. Germain. (*Cah. Phys.*, June 1962, Vol. 16, No. 142, pp. 243–260.) A review of classical treatment, magnetohydrodynamic effects and special conditions under which shock waves occur. 31 references.

537.56 **3995**

Relativistic Nonlinear Theory of Plasma Oscillations.—L. Gold. (*J. Electronics Control*, July 1962, Vol. 13, No. 1, pp. 1–12.) Nonlinear theory is extended into the threshold relativistic region where radiation damping can be neglected. Two procedures are given for delineation of the amplitude-dependent frequency of the fundamental vibration.

537.56: 538.567 **3996**

Polarizing Effect in Nonlinear Plasma Interactions.—L. S. Taylor. (*J. appl. Phys.*, Sept. 1962, Vol. 33, No. 9, pp. 2913–2914.) The effects of the polarizing field in an ionized gas on e.m. wave mixing are considered.

538.561: 537.122 **3997**

Cherenkov Radiation from an Electron Travelling in a Circle through a Dielectric Medium.—A. Erteza & J. J. Newman. (*J. appl. Phys.*, May 1962, Vol. 33, No. 5, pp. 1864–1868.) The theory developed predicts an eigenfrequency spectrum for the radiated energy instead of the continuous spectrum associated with linear trajectories.

538.561: 537.533: 621.385.6 **3998**

Stimulated Emission of Bremsstrahlung.—Marcuse. (See 4245.)

538.566: 535.42 **3999**

The Exact Closed Solution for the Diffraction of a Plane Electromagnetic Wave at a Slot.—H. Stöckel. (*Ann. Phys., Lpz.*, 25th July 1962, Vol. 9, Nos. 5/6, pp. 242–251.)

538.566: 535.42 **4000**

Diffraction of a Plane Wave by a Right-Angled Wedge which Sustains Surface Waves on One Face.—F. C. Karal, Jr, & S. N. Karp. (*Quart. appl. Math.*, July 1962, Vol. 20, No. 2, pp. 97–106.) An extension of previous work (e.g. 3266 of 1959) to a special case in which one face of the wedge is a perfect conductor and the other supports surface waves.

538.566: 535.43 **4001**

Scattering of a Plane Wave by an Infinite Inhomogeneous Dielectric Cylinder—an Application of the Born Approximation.—F. A. Albini & E. R. Nagelberg. (*J. appl. Phys.*, May 1962, Vol. 33, No. 5, pp. 1706–1713.) The scattering and absorption of an obliquely incident plane e.m. wave by an infinite cylindrically symmetrical region characterized by a complex dielectric constant are determined for the case of a dielectric constant near unity.

538.566: 535.43 **4002**

Scattering Theory for Finite-Beam Incidence.—P. J. Lynch & S. Altshuler. (*J. appl. Phys.*, Sept. 1962, Vol. 33, No. 9, pp. 2754–2759.) Mathematical treatment of the small-angle scattering of a beam of plane e.m. waves by a dielectric with variable index of refraction.

538.566: 535.43 **4003**

Scattering from a Conducting Sphere Embedded in a Semi-infinite Dissipative Medium.—J. Galejs. (*J. Res. nat. Bur. Stand.*, Sept./Oct. 1962, Vol. 66D, No. 5, pp. 607–612.) The sphere acts as a combination of horizontal magnetic and electric dipoles.

538.566: 535.43 **4004**

High-Frequency Scattering from a Coated Sphere.—V. H. Weston & R. Hemenger. (*J. Res. nat. Bur. Stand.*, Sept./Oct. 1962, Vol. 66D, No. 5, pp. 613–619.) The scattered field is considered which is produced by a plane wave incident on a perfectly conducting sphere coated with a thin layer of material with large complex refractive index.

538.566: 537.56 **4005**

Propagation Characteristics of Magneto-ionic Plasma Columns.—D. Formato & A. Gilardini. (*J. Res. nat. Bur. Stand.*, Sept. Oct. 1962, Vol. 66D, No. 5, pp. 543–555.) The ratios of plasma wavelength to free-space wavelength, and power flowing in the plasma to power flowing outside are evaluated and discussed.

538.566: 537.56 **4006**

Electromagnetic Wave Propagation along a Conducting Cylinder Surrounded by a Layer of Ionized Air with Negative Electrical Permittivity.—V. I. Zimina. (*Radiotekhnika i Elektronika*, June 1962, Vol. 7, No. 6, pp. 988–994.) Frequencies at which propagation is possible are considered. The dependence of the phase velocity on the electron concentration, and the power distribution and energy losses of the system are discussed.

538.566.029.6: 535.43: 537.56 **4007**

Scattering of Microwaves from a Cylindrical Plasma in the Born Approximation: Part 3.—Y. Midzuno. (*J. phys. Soc. Japan*, Aug. 1962, Vol. 17, No. 8, pp. 1299–1303.) Scattering formulae are derived for the case of a magnetic field applied obliquely. Both electric and magnetic dipoles are considered as the source of the incident microwaves. Part 2: 457 of February.

538.567: 621.372.44 **4008**

Three-Dimensional Parametric Interactions of Waves and Quasi-Particles.—Hsiung Hsu. (*Proc. Inst. Radio Engrs*, Sept. 1962, Vol. 50, No. 9, pp. 1977–1978.) Parametric interaction in a cavity is interpreted as scattering of coherent waves or quantized fields of quasi-particles.

538.569.4: 621.375.9: 535.61-2 **4009**

Measurements of the Output from a Ruby Laser with a Central Hole in One of the End Mirrors.—R. L. Aagard. (*J. appl. Phys.*, Sept. 1962, Vol. 33, No. 9, pp. 2842–2844.) The average transmission of one of the Fabry-Perot mirrors in a ruby laser has been varied by changing the diameter of a hole in the centre of one of the aluminium end coatings. Measurements show that the output is a maximum for a particular value of transmission. The optimum transmission depends upon the input energy. A relation between the optimum transmission and threshold for stimulated emission is shown.

538.569.4: 621.375.9: 535.61-2 **4010**

R.F. Excitation of a Hg-Tl Mixture.—R. Anderson, D. Schricker & J. Patterson. (*J. appl. Phys.*, Sept. 1962, Vol. 33, No. 9, pp. 2904–2905.) Investigation of a possible light source for laser applications.

539.2 **4011**

Relevant and Irrelevant Symmetry Components. Are the Bloch Energy Bands the Best One-Electron Functions?—C. K. Jørgensen. (*Physica status solidi*, 1962, Vol. 2, No. 9, pp. 1146–1150. In English.) The translational symmetry on which band structure is based may be irrelevant, and localized molecular orbitals in clusters of a few adjacent atoms are considered to be more satisfactory.

GEOPHYSICAL AND EXTRATERRESTRIAL PHENOMENA

523.16 **4012**

The Gravitational Concentration of Particles in Space near the Earth.—S. H. Dole. (*Planet. Space Sci.*, Sept. 1962, Vol. 9, pp. 541–553.) In the theory developed the particles are initially in heliocentric orbits which are disturbed by the earth's attraction.

523.164 **4013**

Radio Background as a Criterion for Cosmological Models.—W. Davidson. (*Nature, Lond.*, 13th Oct. 1962, Vol. 196, No. 4850, pp. 155–156.) Steady-state and evolutionary models are considered on the basis of the sky brightness contribution of r.f. sources.

523.164: 539.16 **4014**

Decametric-Wavelength Absorption resulting from the Nuclear Detonation of July 9, 1962.—R. M. Straka, P. G. Elkins & H. A. Strick. (*Nature, Lond.*, 13th Oct. 1962, Vol. 196, No. 4850, pp. 156–157.) 10- and 30-Mc/s riometer records obtained at Hamilton, Mass., are illustrated and discussed.

523.164.3 **4015**

Observations of the Radio Emission of Venus and Jupiter at 8-mm Wavelength.—A. D. Kuz'min & A. E. Salomonovich. (*Astronom. Zh.*, July/Aug. 1962, Vol. 39, No. 4, pp. 660–668.) Results obtained from March to May 1961 using a 22-m radio telescope are reported. The observations of Jupiter allowed the effective aerial aperture to be evaluated.

523.164.3: 523.45 **4016**

Stimulated Electron Spin-Flip Transition as the Source of 18-Mc/s Radiation on Jupiter.—L. Landovitz & L. Marshall. (*Nature, Lond.*, 22nd Sept. 1962, Vol. 195, No. 4847, pp. 1186–1187.) The spin-flip transitions occur when impinging clouds of solar particles cause sudden changes in the local magnetic field.

523.164.32 **4017**

Solar Temperature at 2-mm Wavelength.—D. J. H. Wort. (*Nature, Lond.*, 29th Sept. 1962, Vol. 195, No. 4848, pp. 1288–1289.) A description is given of the technique and apparatus used to measure the apparent temperature of the sun at 2·04 mm λ. A value of 5 670 ± 230°K was obtained.

523.164.32 **4018**

On the Relative Position and Origin of Harmonics in the Spectra of Solar Radio Bursts of Spectral Types II and III.—S. F. Smerd, J. P. Wild & K. V. Sheridan. (*Aust. J. Phys.*, June 1962, Vol. 15, No. 2, pp. 180–193.) Observations indicate a much lower height in the solar atmosphere for the generation of harmonic emission than for the fundamental. Possible interpretations are considered.

523.164.32: 523.75 **4019**

Noise Storms on Wavelength 56 cm.—A. Tlamicha. (*Bull. astr. Insts Csl.*, 1962, Vol. 13, No. 3, pp. 121–122. In English.) Three abnormal solar noise storms observed at Ondřejov, Poland, are described.

523.164.4 **4020**

Polarization of 20-cm-Wavelength Radiation from Radio Sources.—F. F. Gardner & J. B. Whiteoak. (*Phys. Rev. Lett.*, 1st Sept. 1962, Vol. 9, No. 5, pp. 197–199.) Linear polarization of 20-cm radiation has been detected in all but two of the nine extragalactic sources investigated, supporting the hypothesis that the synchrotron mechanism is responsible for radiation from non-thermal sources.

523.164.4 **4021**

Radio Emission from the Cassiopeia 23N5A on 130-cm Wavelength.—A. Tlamicha. (*Bull. astr. Insts Csl.*, 1962, Vol. 13, No. 3, p. 122. In English.)

523.164.4 **4022**

Faraday Rotation Effects associated with the Radio Source Centaurus-A.—B. F. C. Cooper & R. M. Price. (*Nature, Lond.*, 15th Sept. 1962, Vol. 195, No. 4846, pp. 1084–1085.) Measurements on the linearly polarized radiation from Centaurus-A at frequencies from 970 to 3 000 Mc/s show considerable Faraday rotation. Most of the rotation must occur either in our own galaxy or in the outer regions of the source indicating that the magnetic field in these regions must be extremely uniform over very large distances.

523.164.4 **4023**

Polarization in the Central Component of Centaurus-A.—R. N. Bracewell, B. F. C. Cooper & T. E. Cousins. (*Nature, Lond.*, 29th Sept. 1962, Vol. 195, No. 4848, pp. 1289–1290.) Contour diagrams obtained at 10 cm λ using the 210-ft. radiotelescope are illustrated showing the polarized component.

523.165 **4024**

Analysis of Balloon Observations during April 1960 Solar Cosmic-Ray Events.—A. J. Masley, T. C. May & J. R. Winckler. (*J. geophys. Res.*, Aug. 1962, Vol. 67, No. 9, pp. 3243–3268.) A comparison of solar proton data obtained simultaneously from a space probe, a satellite and balloons.

523.165 **4025**

Note on the Electron Energy Spectrum in the Inner Van Allen Belt.—G. Pizzella, C. D. Laughlin & B. J. O'Brien. (*J. geophys. Res.*, Aug. 1962, Vol. 67, No. 9, pp. 3281–3287.) The energy spectrum of trapped electrons predicted by the neutron-albedo theory has been tested experimentally, and the results are found to disagree with these predictions.

523.165 **4026**

The Outer Radiation Belt of the Earth at an Altitude of 320 km.—N. Vernov, I. A. Savenko, P. I. Shavrin, V. E. Nesterov & N. F. Pisarenko. (*Dokl. Ak. Nauk S.S.S.R.*, 1st Oct. 1961, Vol. 140, No. 4, pp. 787–790.) Maps show the intensity distribution of the radiation belt surrounding the earth as recorded by counters on the second and third Soviet artificial satellites. At a height of 300 km the atmospheric density is $3 \cdot 5 \times 10^9$ atoms/cm³ and electrons of energies of 10^5 eV have a lifetime of only few seconds.

523.165 **4027**

The Discovery of an Inner Radiation Belt at an Altitude of 320 km in the Region of the South-Atlantic Magnetic Anomaly.—S. N. Vernov, I. A. Savenko, P. I. Shavrin & N. F. Pisarenko. (*Dokl. Ak. Nauk S.S.S.R.*, 11th Oct. 1961, Vol. 140, No. 5, pp. 1041–1044.) A map shows the radiation belt as passing over South America and the South Atlantic. Near the coast of Brazil the strength of the magnetic field, as recorded by the second cosmic vehicle, reached 0·25 oersteds. Tables give the data used in mapping the regions of the magnetic anomaly. See also *ibid.*, 1st Oct. 1961, Vol. 140, No. 4, pp. 783–786.

523.165 **4028**

Re-entrant Cosmic-Ray Albedo.—E. C. Ray. (*J. geophys. Res.*, Aug. 1962, Vol. 67, No. 9, pp. 3289–3291.) An expression is derived for the intensity.

523.165 **4029**

Synchrotron Radiations from Van Allen Belts Expected to be Observed in the Ionosphere.—T. Takakura. (*Rep. Ionos. Space Res. Japan*, Dec. 1961, Vol. 15, Nos. 3/4, pp. 314–318.) Quantitative estimates of the power likely to be received.

523.165 **4030**

Investigations on the Mechanism of the Cosmic-Ray Storm.—M. Kitamura. (*Rep. Ionos. Space Res. Japan*, Dec. 1961, Vol. 15, Nos. 3/4, pp. 374–410.) To explain the latitude variation in the Forbush decrease, a diffusion mechanism is insufficient. An alternative model is proposed.

523.165: 550.385.4 **4031**

On Cosmic-Ray Intensity Increase during Geomagnetic Storm.—I. Kondō. (*Rep. Ionos. Space Res. Japan*, Dec. 1961, Vol. 15, Nos. 3/4, pp. 319–345.) A statistical analysis of a number of storms especially those on 13th September 1957 and 11th February 1958.

523.3: 621.396.96 **4032**

A Theory of Radar Reflections from a Rough Moon.—D. F. Winter. (*J. Res. nat. Bur. Stand.*, May/June 1962, Vol. 66D, No. 3, pp. 215–226.) The proposition that the lunar echo is comprised of scattering from two general types of terrain is discussed in the light of experimental results.

523.42 : 621.396.96 **4033**

Radar Observation of Venus.—V. A. Kotel'nikov, V. M. Dubrovin, M. D. Kislik, E. B. Korenberg, V. P. Minashin, V. A. Morozov, N. I. Nikitskiĭ, G. M. Petrov, O. N. Rzhiga & A. M. Shakhovskoĭ. (*Dokl. Ak. Nauk S.S.S.R.*, 11th Aug. 1962, Vol. 145, No. 5, pp. 1035–1038.) A report of observations made at 700–750 Mc/s with a power output of 250 MW, giving a power of 15 W at the surface of Venus. A possibility is considered that the wideband component of the received signal is due to reflection from strongly ionized streams moving with a velocity of ± 40 m/s relative to Venus.

523.5 : 621.391.8 **4034**

Amplitude Distribution for Radio Signals Reflected by Meteor Trails: Part 2.—A. D. Wheelon. (*J. Res. nat. Bur. Stand.*, May/June 1962, Vol. 66D, No. 3, pp. 241–247.) The bivariate probability distribution for two composite meteor signals is derived. By making certain assumptions relative to the nature of the signal, an expression, involving elliptic functions, is obtained. Part 1: 105 of January.

523.7 **4035**

The Static and the Slowly Varying Radiation Component of the Sun at a Wavelength of 8 cm.—H. Urbarz. (*Frequenz*, June & July 1962, Vol. 16, Nos. 6 & 7, pp. 229–234 & 250–262.) Report of the results of the continuous recording of total solar radiation at 3 750 Mc/s over a period of 5 months by means of a 3-m radio telescope at Tübingen. The measurement procedure is outlined and the underlying theory discussed. The diurnal averages obtained are closely correlated with values recorded at Toyokawa, Japan, and with relative sunspot numbers.

550.38 : 523.75 **4036**

The Magnetic Effects of Magnetosphere Surface Currents.—D. B. Beard & E. B. Jenkins. (*J. geophys. Res.*, Aug. 1962, Vol. 67, No. 9, pp. 3361–3367.) An extension of previous calculations [see 1916 of June (Beard)] to determine the magnetic field due to surface currents.

550.385 : 550.37 **4037**

Theory of Magneto-telluric Fields.—J. R. Wait. (*J. Res. nat. Bur. Stand.*, Sept./Oct. 1962, Vol. 66D, No. 5, pp. 509–541.) A review of the present state of knowledge, in which various suggestions for the source mechanism of the fields are discussed and work on the theory of the magneto-telluric interpretation is examined.

550.385.37 **4038**

Hydromagnetic Emissions, X-Ray Bursts, and Electron Bunches: Part 1—Experimental Results.—L. R. Tepley & R. C. Wentworth. (*J. geophys. Res.*, Aug. 1962, Vol. 67, No. 9, pp. 3317–3333.) Recent data on two classes of micropulsations, viz. hydromagnetic emissions and noise bursts, are presented, relating to their occurrence, their structure and the dependence of emission frequency on latitude.

550.385.37 **4039**

Hydromagnetic Emissions, X-Ray Bursts, and Electron Bunches: Part 2—Theoretical Interpretation.—R. C. Wentworth & L. R. Tepley. (*J. geophys. Res.*, Aug. 1962, Vol. 67, No. 9, pp. 3335–3343.) A model is presented covering certain aspects of the motion of geomagnetically trapped electrons relevant to the production of hydromagnetic emissions by electron bunches.

550.385.37 **4040**

A Note on the Classification of Geomagnetic Signals below 30 Cycles per Second.—J. E. Lokken, J. A. Shand & C. S. Wright. (*Canad. J. Phys.*, Aug. 1962, Vol. 40, No. 8, pp. 1000–1009.) Simultaneous measurements in the frequency range 0·003–30 c/s at a number of widely spaced stations have led to the identification of two general micropulsation classes, impulsive and regular, as well as to an adjacent but independent extremely-low-frequency background. The signal bandwidths and the dependence on geomagnetic latitude and longitude serve to distinguish the classes.

550.385.37 **4041**

Geomagnetic Pulsations and the Earth's Exosphere.—T. Tamao. (*Rep. Ionos. Space Res. Japan*, Dec. 1961, Vol. 15, Nos. 3/4, pp. 293–313.) A qualitative study of the mechanism of geomagnetic pulsations.

551.507.362.1 : 550.380.8 **4042**

A Comparison of Solar-Flare Incidence with Magnetic Transients Observed in the Near-By Interplanetary Region by Pioneer V.—E. W. Greenstadt & G. E. Moreton. (*J. geophys. Res.*, Aug. 1962, Vol. 67, No. 9, pp. 3299–3316.) Temporal fluctuations in the interplanetary magnetic field were correlated in time with the occurrence of H_α flare activity.

551.507.362.2 **4043**

Determination of the Osculating Elements of the Orbit of an Artificial Satellite.—J. Kovalevsky & F. Barlier. (*C. R. Acad. Sci., Paris*, 27th Feb. 1961, Vol. 252, No. 9, pp. 1273–1275.) The determination of the orbit of a satellite from a set of observations made at three different points on the earth surface is simplified by first determining the osculatory elements of the orbit.

551.507.362.2 **4044**

On Near-Circular Orbits of Artificial Earth Satellites.—V. G. Demin. (*Isk. Sput. Zemli*, 1961, No. 8, pp. 57–63. English translation, *Planet. Space Sci.*, Sept. 1962, Vol. 9, pp. 557–563.) A method of computing near-circular orbits is suggested which takes account of the perturbing forces of the sun and moon. The analysis follows that of the four-body problem.

551.507.362.2 **4045**

Atmospheric Density Variations in the 205-km Height Region from Sputnik III Satellite.—B. R. May. (*Planet. Space Sci.*, Sept. 1962, Vol. 9, pp. 529–540.) An analysis of data derived from the period/time curve of Sputnik III shows that the air density at 205 km displays variations associated with solar ultraviolet flux and geomagnetic activity, and an annual and semi-annual component of uncertain origin.

551.507.362.2 **4046**

Charge Drag on Project West Ford Needles.—D. B. Beard. (*J. geophys. Res.*, Aug. 1962, Vol. 67, No. 9, pp. 3293–3297.) A detailed analysis of the estimated charge drag gives a result which is an order of magnitude greater than the neutral drag at the proposed altitude of 3 700 km.

551.507.362.2 : 539.16 **4047**

Satellite Observations of the Energetic Particle Flux produced by the High-Altitude Nuclear Explosion of July 9, 1962.—A. C. Durney, H. Elliot, R. J. Hynds & J. J. Quenby. (*Nature, Lond.*, 29th Sept. 1962, Vol. 195, No. 4848, pp. 1245–1248.) A preliminary analysis of results obtained from a Geiger counter carried in Ariel.

551.510.53 **4048**

The U.S. Standard Atmosphere, 1962.—N. Sissenwine, M. Dubin & H. Wexler. (*J. geophys. Res.*, Aug. 1962, Vol. 67, No. 9, pp. 3627–3630.) Details of the proposed model are given for heights up to 700 km.

551.510.53 **4049**

Time-Dependent Structure of the Upper Atmosphere.—I. Harris & W. Priester. (*J. atmos. Sci.*, July 1962, Vol. 19, No. 4, pp. 286–296.) Heat conduction in the upper atmosphere is discussed. Two heat sources, viz. solar ultraviolet and corpuscular radiations, are required to account for diurnal and semiannual variations in the atmosphere, and the effects of solar and geomagnetic activity.

551.510.535 **4050**

Joule Heating of the Upper Atmosphere.—K. D. Cole. (*Aust. J. Phys.*, June 1962, Vol. 15, No. 2, pp. 223–235.) The Joule heating and motion of uniform ionized gas are discussed on the assumption that uniform electric and mechanical force fields are orthogonal to the magnetic field. The theory is applied to the ionosphere during a geomagnetic disturbance. See 1942 of June.

551.510.535 **4051**

A Resonance Property of the Ionosphere due to its Anisotropic Conductivity.—A. T. Price & G. A. J. Ferris. (*Nature, Lond.*, 20th Oct. 1962, Vol. 196, No. 4851, pp. 258–260.) The currents induced in a nonisotropic spherical shell model of the ionosphere by an oscillating field of external origin can be greater than those which would be induced in an isotropic shell of infinite conductivity.

551.510.535 **4052**

The Validity of an Approximation to the Magneto-ionic Formulae when $\nu > 3\nu_c$.—Y. S. N. Murty. (*J. Instn Telecommun. Engrs, India*, July 1962, Vol. 8, No. 4, pp. 186–188.) Simplified expressions for the principal parameters of the Appleton-Hartree formula are derived which are valid for vertical sounding stations in the region of Pennsylvania.

551.510.535 **4053**

Induction of Electric Currents in a Uniform Anisotropic Ionosphere.—A. A. Ashour & V. C. A. Ferraro. (*Nature, Lond.*, 20th Oct. 1962, Vol. 196, No. 4851, p. 260.) The anisotropy modifies that part of the inducing field which is asymmetrical with the geomagnetic field. This modified part rotates about the geomagnetic axis from west to east at a rate which depends on the Hall conductivity.

551.510.535 **4054**

Diurnal and Seasonal Changes in Structure of the Mid-Latitude Quiet Ionosphere.—J. W. Wright. (*J. Res. nat. Bur. Stand.*, May/June 1962, Vol. 66D, No. 3, pp. 297–312.) The properties of the F region over various areas between latitudes 15° and 50°N are deduced from electron-density determinations. Diurnal, seasonal and latitudinal variations are explained in terms of changes in temperature associated with these variables.

551.510.535 **4055**

Ionospheric Ionization at Night (Corpuscular Hypothesis).—G. S. Ivanov-Kholodnyĭ & L. A. Antonova. (*Dokl. Ak. Nauk S.S.S.R.*, 11th Oct. 1961, Vol. 140, No. 5, pp. 1062–1065.) Brief study of the ionized layer of the atmosphere which is supposed to be caused by solar radiation at wavelengths <900 Å. A table gives the calculated values of the electron density distribution for ionospheric heights between 90 and 290 km.

551.510.535 **4056**

Investigation of the Lower Ionosphere by means of Long Radio Waves and Low-Frequency Radiosondes placed on Rockets: Detection of a New Ionosphere Layer.—P. E. Krasnushkin & N. L. Kolesnikov. (*Dokl. Ak. Nauk S.S.S.R.*, 21st Sept. 1962, Vol. 146, No. 3, pp. 596–599.) Results of measurements carried out in 1958 and 1959 by two rockets at heights of 50–100 km, indicate the existence of a layer between 57–67 km in summer and 57–80 km in winter. This layer, the C layer, does not depend on the time of the day or season but on latitude. In the equatorial zones the C layer is not observed.

551.510.535 **4057**

Drift Measurements with the Aid of Measurements of Long-Wave Propagation.—H. Koch & R. Schminder. (*Geofis. pura appl.*, Jan.–April 1962, Vol. 51, No. 1, pp. 214–216. In German.) Drift measurements made by the Krautkrämer method (3144 of 1950) and field-strength recordings taken during the period October 1960–October 1961 on transmissions at 272 kc/s have been analysed. Under certain conditions, the field-strength bursts observed can be used to derive the drift velocity of E-layer disturbances.

551.510.535 **4058**

Rapid Variations in the Sporadic-E Region.—L. H. Heisler & J. D. Whitehead. (*J. atmos. terr. Phys.*, Sept. 1962, Vol. 24, pp. 753–764.) Ionograms taken every 7·8 s have been analysed to study E_s parameters. The effects are interpreted to show details of the layer structure.

551.510.535 **4059**

Auroral Sporadic-E Ionization.—R. D. Hunsucker & L. Owren. (*J. Res. nat. Bur. Stand.*, Sept./Oct. 1962, Vol. 66D, No. 5, pp. 581–592.) Comparison of all-sky camera photographs and ionograms, and studies of statistical relations between fE_s, the auroral activity index and the local magnetic *K*-index were made. A correlation coefficient of 0·544 was found between zenithal auroral activity and values of fE_s.

551.510.535 **4060**

Photo-ionization Rates in the E and F Regions: Part 2.—H. E. Hinteregger & K. Watanabe. (*J. geophys. Res.*, Aug. 1962, Vol. 67, No. 9, pp. 3373–3392.) Rocket observations of solar radiation between 280 Å and 1 350 Å are discussed, and rates of photo-ionization derived. The E-region ionization is mainly due to radiation at wavelengths > 911 Å. Part 1: 2309 of July (Watanabe & Hinteregger).

551.510.535 **4061**

Total Electron Content in F2 Layer over Madras during 1959.—C. S. R. Rao & M. Sain. (*J. Instn Telecommun. Engrs, India*, July 1962, Vol. 8, No. 4, pp. 179–185.) Original data obtained by All India Radio over the period February 1959–January 1960 are analysed with reference to variations of total electron content, maximum electron density, scale height and temperature of the F2 layer.

551.510.535 **4062**

Evidence for a Further Ionospheric Ledge Above the F2 Region.—J. Sayers, P. Rothwell & J. H. Wager. (*Nature, Lond.*, 22nd Sept. 1962, Vol. 195, No. 4847, pp. 1143–1145.) Direct measurements of the local ionization density along the path of the satellite Ariel between apogee and perigee yield 'profiles' of electron density on every one of which a ledge of ionization is found.

551.510.535 **4063**

Enhancement of the Lunar Tide in the Noon Critical Frequency of the F2 Layer over the Magnetic Equator.—R. G. Rastogi. (*J. Res. nat. Bur. Stand.*, Sept./Oct. 1962, Vol. 66D, No. 5, pp. 601–606.) The lunar semi-diurnal variations of f_0F2 and the height of maximum electron density are derived for the two chains of equatorial stations in South America and India, for the period 1957–1958. The enhancement noted appears to be associated with the equatorial electrojet.

551.510.535 **4064**

Spread-F and the Perturbations of the Maximum Electron Density of the F Layer.—D. G. Singleton. (*Aust. J. Phys.*, June 1962, Vol. 15, No. 2, pp. 242–260.) The dominant effect influencing the diurnal and seasonal variations of spread-F at all latitudes is that the spread Δf_E is a maximum when f_c is a minimum.

551.510.535 **4065**

Classification of Spread-F Ionograms.—R. Penndorf. (*J. atmos. terr. Phys.*, Sept. 1962, Vol. 24, pp. 771–778.) Five types of spread-F are distinguished, based on their appearance on ionograms. Records for one day are analysed to indicate their relative frequency of occurrence.

551.510.535 **4066**

Geomagnetic Control of Diffusion in the F2 Region of the Ionosphere: Part 1—The Form of the Diffusion Operator.—P. C. Kendall. (*J. atmos. terr. Phys.*, Sept. 1962, Vol. 24, pp. 805–811.) A theoretical derivation of equations governing the diffusion of ionization along geomagnetic field lines, with special reference to the magnetic equator.

551.510.535 **4067**

Investigations of the Diurnal and Seasonal Variations of the Plasma of the Outer Ionosphere and their Theoretical Interpretation.—K. H. Schmelovsky. (*Z. Geophys.*, 1961, Vol. 27, No. 2, pp. 59–66.) A theoretical model of the F2 layer and outer ionosphere is based on the results of satellite measurements of Faraday fading. Seasonal variations are attributed to thermal diffusion of electrons and protons from the summer to the winter hemisphere.

551.510.535: 523.165 **4068**

Solar Cosmic Rays of July 1961 and their Ionospheric Effects.—B. Maehlum & B. J. O'Brien. (*J. geophys. Res.*, Aug. 1962, Vol. 67, No. 9, pp. 3269–3279.) Satellite measurements of solar proton flux are used to calculate ionization expected in the D region. Electron density measurements confirm the result.

551.510.535: 523.745 **4069**

On Ionospheric Disturbances caused by the Solar Activity of November 1960.—M. Anastassiades, D. Ilias & E. Tsagakis. (*Geofis. pura appl.*, Jan.–April 1962, Vol. 51, No. 1, pp. 142–146. In English.) Riometer recordings on 27·6 and 58 Mc/s and vertical ionospheric soundings taken at Athens are discussed and the latter related to simultaneous f_0F2 records obtained at Slough. Other periods of solar activity are also mentioned and the phenomena compared.

551.510.535: 523.75 **4070**

Coincidence of Sudden Ionospheric Disturbances with the Explosive Phase of Solar Flares.—R. Hansen & J. Kleczek. (*Nature, Lond.*, 29th Sept. 1962, Vol. 195, No. 4848, pp. 1280–1281.) Report and discussion of ionospheric effects associated with 10·7-cm solar noise bursts coincident with the explosive phase of solar flares [4087 of 1961 (Covington & Harvey)].

551.510.535: 523.78 **4071**

The Ionosphere over Genova [Genoa] **during the Solar Eclipse of February 15, 1961.**—M. Bossolasco & A. Elena. (*Geofis. pura appl.*, Jan.–April 1962, Vol. 51, No. 1, pp. 155–165. In English.) Pronounced E-layer effects were observed, but the F2-layer effects were partly obscured by the simultaneous occurrence of an ionospheric disturbance. The maximum reduction of ionospheric absorption at 2 and 3 Mc/s during the eclipse was found to be about 12 db.

551.510.535: 537.56 **4072**

Investigation of Ion Oscillations of Plasma. Their Role in the Mechanism responsible for Ionospheric Winds.—D. Lepechinsky & P. Rolland. (*J. atmos. terr. Phys.*, Sept. 1962, Vol. 24, pp. 813–822.)

It is suggested that plasma oscillations are the source of the irregularities observed in measurements of ionospheric winds.

551.510.535: 539.16 **4073**

Widespread Ionospheric Disturbances due to Nuclear Explosions during October 1961.—T. Obayashi. (*Nature, Lond.*, 6th Oct. 1962, Vol. 196, No. 4849, pp. 24–27.) Ionospheric data from about 30 stations at the times of the explosions are illustrated. The nature of the travelling disturbance wave is discussed.

551.510.535: 539.16 **4074**

Ionospheric Effects of Nuclear Explosions.—W. J. G. Beynon & E. S. O. Jones. (*Nature, Lond.*, 20th Oct. 1962, Vol. 196, No. 4851, pp. 253–254.) Data providing additional information to that obtained at Lindau [1557 of May (Dieminger & Kohl)] are derived from recordings made at 15-min intervals at Aberystwyth, Wales, 3 570 km from the source.

551.510.535: 539.16 **4075**

Spread-F Development Associated with a High-Altitude Nuclear Explosion.—L. H. Heisler & L. D. Wilson. (*Nature, Lond.*, 20th Oct. 1962, Vol. 196, No. 4851, p. 258.) An ionogram from a panoramic ionosonde taken two minutes after the explosion of a high-altitude thermonuclear device shows a development of spread-F at a rate much greater than any previously recorded.

551.510.535: 550.385 **4076**

Correlation between Sporadic-E Ionization and the Strength of the Horizontal Component of the Earth's Magnetic Field.—J. R. Wilkie & R. W. E. McNicol. (*Aust. J. Phys.*, June 1962, Vol. 15, No. 2, pp. 236–241.) The correlation is shown to exist even when the effects of different diurnal variations of E_s and H are removed.

551.510.535: 550.385.4 **4077**

Magnetic Field of the F Region from $h'(f)$ Records.—R. N. Singh & S. K. Tolpadi. (*J. atmos. terr. Phys.*, Sept. 1962, Vol. 24, pp. 824–826.) Values of f_0F and f_xF are used to study fluctuations of the magnetic field during a disturbance.

551.510.535: 550.386 **4078**

A Note on Geomagnetic and Ionospheric Records.—J. A. Shand. (*Canad. J. Phys.*, Aug. 1962, Vol. 40, No. 8, pp. 1046–1048.) A relation between magnetic activity and electron density is demonstrated for both upper and lower levels in the ionosphere.

551.510.535: 551.594.5 **4079**

Ionospheric D-Region Phenomena associated with Auroral Disturbances at Sodankylä.—W. Dieminger, J. Oksman & G. Rose. (*J. atmos. terr. Phys.*, Sept. 1962, Vol. 24, pp. 823–824.) Ionograms taken at Sodankylä, Finland, 2nd–3rd December 1961, during a strong auroral disturbance are reproduced.

551.510.535: 621.3.087.4 **4080**

Automatic Registration of Critical-Frequency Variation of Ionospheric Layers.—J. K. Sen. (*J. Instn Telecommun. Engrs, India*, July 1962, Vol. 8, No. 4, pp. 197–201.) Modifications to existing ionospheric recorders are described by which the diurnal variation of critical frequency can be recorded automatically on a single chart.

551.510.535: 621.391.812.63 **4081**

The Screening Effect of the Ionosphere.—B. C. Potts. (*Proc. Inst. Radio Engrs*, Sept. 1962, Vol. 50, No. 9, p. 1980.) The importance is stressed of allowing for ionospheric screening in statistical studies of c.w. reflection from the vicinity of artificial earth satellites. Contours of areas of possible reflection at various satellite heights are shown.

551.510.536 **4082**

Ionization above the F2 Peak as Affected by the Interplanetary Gas.—S. Chapman. (*Geofis. pura appl.*, Jan.–April 1962, Vol. 51, No. 1, pp. 147–154. In English.) The atmospheres of the earth, the sun and other bodies are surrounded by gas, the 'ambium', that is nearly uniform in number density and kinetic temperature over spaces much greater than those occupied by the atmospheres. Evidence presented indicates that the earth's ambium may be ionized solar atmospheric hydrogen. Divergent opinions of other authors are discussed.

551.510.536: 551.594.6 **4083**

Electron-Density Variations in the Magnetosphere deduced from Whistler Data.—D. L. Carpenter. (*J. geophys. Res.*, Aug. 1962, Vol. 67, No. 9, pp. 3345–3360.) Electron-density variations at a geocentric distance of 2–4 earth radii are deduced from whistler observations at Stanford, California, and Seattle, Washington.

551.594.5: 550.385.4 **4084**

Large-Scale Auroral Motions and Polar Magnetic Disturbances: Part 3—The Aurora and Magnetic Storm of 11 February 1958.—S. I. Akasofu & S. Chapman. (*J. atmos. terr. Phys.*, Sept. 1962, Vol. 24, pp. 785–796.) All-sky camera records taken in North America, Siberia and Japan are used to study the changes the distribution of aurorae during the storm. Part 2: 3715 of November (Akasofu).

551.594.6 **4085**

Cyclotron Theory of Very-Low-Frequency Discrete Emissions.—R. L. Dowden. (*Nature, Lond.*, 15th Sept. 1962, Vol. 195, No. 4846, pp. 1085–1086.) The theory that Doppler-shifted cyclotron radiation from receding electrons would give the observed frequency time characteristic of discrete v.l.f. emissions is supported by comparing theoretical curves with observations of hook-type emissions. Sequences of 'hooks' caused by the electron bunch being reflected several times between the two hemispheres are discussed.

551.594.6 **4086**

Diurnal and Cyclic Variations of the Intensity of Natural Radio Noise at Very Low Frequencies.—C. Renard. (*C. R. Acad. Sci., Paris*, 27th Feb. 1961, Vol. 252, No. 9, pp. 1365–1367.) A discussion of the variations of dawn chorus and hiss shown in an analysis of records obtained at Kerguelen (geomagnetic latitude 57°2′S) from May 1959–May 1960.

551.594.6 **4087**

On the Theory of Hybrid Whistlers.—H. Unz. (*J. atmos. terr. Phys.*, Sept. 1962, Vol. 24, pp. 765–770.) Theory developed previously (*Trans. Inst. Radio Engrs*, July 1962, Vol. AP-10, No. 4, pp. 459–464) is used to support a new hypothesis. The multiple, discrete, well-defined components in the nose whistlers may be due to different electron streams with discrete velocities along the same geomagnetic line.

LOCATION AND AIDS TO NAVIGATION

621.396.96 **4088**

Scattering from Random Linear Arrays with Closest Approach.—Z. A. Melzak. (*Quart. appl. Math.*, July 1962, Vol. 20, No. 2, pp. 151–159.) A geometrical approach to the problem of determining the probability density for the components of the scattered signal. Results are applicable to radar and sonar echoes.

621.396.962.3 **4089**

On the Use of Pulse Compression for the Enhancement of Radar Echoes from Diffuse Targets.—D. Fryberger. (*Proc. Inst. Radio Engrs*, Sept. 1962, Vol. 50, No. 9, pp. 1993–1994.) The target considered is a weather cloud composed of water droplets of various sizes. Although the compression process increases the magnitude of signal return from each target element, the number of individual returns that come in simultaneously is proportionately reduced, so that the total time waveform remains unchanged.

MATERIALS AND SUBSIDIARY TECHNIQUES

535.215 **4090**

Photo-e.m.f. of *p-n* Junction with Uneven Illumination.—T. Ya. Gorbach, Z. S. Gribnikov & K. M. Krolevets. (*Radiotekhnika i Elektronika*, June 1962, Vol. 7, No. 6, pp. 1020–1029.)

535.215 **4091**

A.C. Impedance Measurements of Photoconductors containing Blocking Layers Analysed by the Maxwell-Wagner Theory.—P. Mark & H. P. Kallmann. (*J. Phys. Chem. Solids*, Aug. 1962, Vol. 23, pp. 1067–1078.) A spread of conductivities exists over the grains, which is roughly Gaussian. For low excitation the capacitance of the conducting portion is not constant; this is attributed to the finite thickness of the layers of charge carriers at the grain boundaries.

535.215: 546.47'221 **4092**

Electron-Bombardment Conductivity in Zinc Sulphide.—W. Ehrenberg & N. J. Hidden. (*J. Phys. Chem. Solids*, Aug. 1962, Vol. 23, pp. 1135–1145.)

535.215: 546.48'221 **4093**

Surface Photovoltage Measurements on Cadmium Sulphide.—R. Williams. (*J. Phys. Chem. Solids*, Aug. 1962, Vol. 23, pp. 1057–1066.)

535.215: 546.48'221 **4094**

Measurement of the Photoelectric Volta Potential on CdS Crystals.—O. Dehoust. (*Z. angew. Phys.*, July 1962, Vol. 14, No. 7, pp. 404–408.) Measurements of contact potential were carried out on illuminated plate-shaped specimens with different metal electrodes and over a wavelength range 3 600–7 000 Å. The influence of internal polarization effects is discussed.

537.227: 547.476.3: 539.12.04 **4095**

On the Effects of X-Ray Irradiation on Transient Phenomena in Rochelle Salt.—T. Rewaj. (*Physica status solidi*, 1962, Vol. 2, No. 9, pp. 1151–1157. In English.) The considerable effects noted are attributed to the immobilization of domains which then no longer contribute to the polarization of the specimen.

537.227: 621.372.44 **4096**

Variation of Dielectric Constant with Voltage in Ferroelectrics and its Application to Parametric Devices.—K. M. Johnson. (*J. appl. Phys.*, Sept. 1962, Vol. 33, No. 9, pp. 2826–2831.) The loss tangent of a ferroelectric in the paraelectric state is proportional to frequency. Since the power-handling capacity of single-crystal ferroelectrics is practically unlimited they may replace varactors in parametric devices.

537.228.1: 549.514.51 **4097**

Dielectric Anomaly in Quartz for High Transient Stress and Field.—R. A. Graham. (*J. appl. Phys.*, May 1962, Vol. 33, No. 5, pp. 1755–1758.) The piezoelectric behaviour of negatively-oriented quartz in the stress range 5–50 kilobars is investigated.

537.228.1: 621.317.39 **4098**

The 'Grain of Sand' Method for Determining the Piezomodulus of a Crystal.—A. D. Brodskii & A. G. Sergeev. (*Akust. Zh.*, 1961, Vol. 7, No. 1, pp. 89–90.) The method outlined is based on the separation of a metal ball from the surface of the crystal as the amplitude of vibrations increases.

537.311.32 + 537.311.33 **4099**

Anomalous Mobility Effects in some Semiconductors and Insulators.—L. R. Weisberg. (*J. appl. Phys.*, May 1962, Vol. 33, No. 5, pp. 1817–1821.) Large inhomogeneities in the impurity distribution greatly enhance Coulomb scattering, causing the low mobilities observed.

537.311.32 + 537.311.33 **4100**

Injection Currents in Insulators.—M. A. Lampert. (*Proc. Inst. Radio Engrs*, Aug. 1962, Vol. 50, No. 8, pp. 1781–1796.) The principles underlying the flow of one- and two-carrier volume-controlled injection currents are reviewed, including the problem of double injection in semiconductors.

537.311.32 **4101**

Trap Density Determination by Space-Charge-Limited Currents.—R. H. Bube. (*J. appl. Phys.*, May 1962, Vol. 33, No. 5, pp. 1733–1737.) Values of trap depth and density derived from measurements of space-charge-limited current are compared with those obtained from thermally stimulated currents and from photocurrent decay on the same crystal of CdS. Care is necessary in using space-charge-limited current data.

537.311.32: 539.23 **4102**

Low-Frequency Negative Resistance in Thin Anodic Oxide Films.—T. W. Hickmott. (*J. appl. Phys.*, Sept. 1962, Vol. 33, No. 9, pp. 2669–2682.) Electrical properties of films between 150 and 1 000 Å thick are investigated.

537.311.33 **4103**

Energy Bands in Semiconductors.—D. Long. (*J. appl. Phys.*, May 1962, Vol. 33, No. 5, pp. 1682–1696.) A review with 136 references.

537.311.33 **4104**

Ionized-Impurity Scattering in Semiconductors.—G. L. Hall. (*J. Phys. Chem. Solids*, Aug. 1962, Vol. 23, pp. 1147–1151.) By evaluation of a certain integral, corrections can be applied to the Brooks-Herring, Conwell-Weisskopf and Takimoto expressions for the mobility of conduction electrons in semiconductors. The associated scattering potentials are derived.

537.311.33 **4105**

Analytic Solution of the Multiple-Diffusion Problem.—R. C. Wackwitz. (*J. appl. Phys.*, Sept. 1962, Vol. 33, No. 9, pp. 2909–2910.) The solution derived is applicable to the case of low-concentration diffusion in many semiconductors.

537.311.33 **4106**

Hot-Electron Emission from Semiconductors.—R. J. Hodgkinson. (*Solid-State Electronics*, Sept./Oct. 1962, Vol. 5, pp. 269–272.) In Si the emission pattern is closely related to the microplasma pattern in the *p-n* junction; electrons are emitted across the thin *n*-type surface layer. In SiC, only peripheral emission is observed.

537.311.33 **4107**

Observations of Instability in Semiconductors caused by Heavily Injected Minority Carriers.—M. Kikuchi & Y. Abe. (*J. phys. Soc. Japan*, Aug. 1962, Vol. 17, No. 8, pp. 1268–1280.) The instability is associated with a 'cloud' of holes in the material.

537.311.33: 534.2 **4108**

Propagation of Space-Charge Acoustic Waves in Semiconductors.—M. E. Gertsenshtein & V. I. Pustovoit. (*Radiotekhnika i Elektronika*, June 1962, Vol. 7, No. 6, pp. 1009–1013.) The propagation of longitudinal acoustic waves in semiconductors is considered. In the presence of a constant external field resulting in carrier drift a negative conductivity is possible.

537.311.33: 537.323 **4109**

Thermoelectric Figure of Merit of Two-Band Semiconductors.—R. Simon. (*J. appl. Phys.*, May 1962, Vol. 33, No. 5, pp. 1830–1841.) Mathematical analysis of the thermoelectric characteristics of semiconductor materials. The possible existence of an upper limit to the figure of merit is discussed.

537.311.33: 537.323 **4110**

Electrical and Thermal Properties of Materials in the System As_2Te_3-TlTe-As_2Se_3.—H. L. Uphoff & J. H. Healy. (*J. appl. Phys.*, Sept. 1962, Vol. 33, No. 9, pp. 2770–2773.) See also 3021 of 1961.

537.311.33: 538.63 **4111**

Theory of Nonlinear Galvanomagnetic Phenomena in Semiconductors.—R. F. Kazarinov & V. G. Skobov. (*Zh. eksp. teor. Fiz.*, April 1962, Vol. 42, No. 4, pp. 1047–1053.) A theoretical treatment of current flow in a semiconductor in strong crossed electric and magnetic fields.

537.311.33 : 538.66 **4112**

Ambielectric Thermomagnetic Effects and Electronic Relaxation Mechanism in III-V Compounds.—M. Rodot. (*C.R. Acad. Sci., Paris*, 24th April 1961, Vol. 252, No. 17, pp. 2526–2528.)

537.311.33: 546.193'221 **4113**

Space-Charge-Limited Currents in Amorphous Arsenic Trisulphide.—C. Bowlt. (*Proc. phys. Soc.*, 1st Sept. 1962, Vol. 80, No. 515, pp. 810–811.) *I/V* curves for amorphous fibres of As_2S_3 show an ohmic relation at low but not at high voltages.

537.311.33: 546.23 **4114**

The Electrical Characteristics of Internal Grain Boundaries in Selenium.—H. Gobrecht, A. Tausend & H. Schmidt. (*Z. angew. Phys.*, Aug. 1962, Vol. 14, No. 8, pp. 453–458.) The results of probe measurements on twin crystals are discussed.

537.311.33: 546.28 **4115**

Diffusant Impurity-Concentration Profiles in Thin Layers on Silicon.—P. A. Iles & B. Leibenhaut. (*Solid-State Electronics*, Sept./Oct. 1962, Vol. 5, pp. 331–339.) The impurity distribution determined by an etch-sectioning method shows wide deviation from a complementary-error-function distribution. Differences are observed from those evaluated by other groups.

537.311.33: 546.28 **4116**

Cross-Sections and Ohmic Resistance of Diffusion Pipes in Silicon.—A. Goetzberger & C. Stephens. (*J. electrochem. Soc.*, July 1962, Vol. 109, No. 7, pp. 604–607.) Experiments on diffusion pipes introduced deliberately by P contamination gave results in agreement with the simple diffusion-model theory.

537.311.33: 546.28 **4117**

Characteristics of *p-i-n* Junctions Produced by Ion-Drift Techniques in Silicon.—J. W. Mayer. (*J. appl. Phys.*, Sept. 1962, Vol. 33, No. 9, pp. 2894–2902.) Li in *p*-type Si was used in the preparation of the junctions, and highly compensated intrinsic regions 0·1 5 mm thick were obtained.

537.311.33: 546.28 **4118**

Investigation of Excess Reverse Currents and Field Effect on Si *p-n* Junctions.—R. O. Litvinov & Syui-Dun-lyan. (*Radiotekhnika i Elektronika*, June 1962, Vol. 7, No. 6, pp. 1030–1036.)

537.311.33: 546.28: 537.228.1 **4119**

The Application of the Piezoresistance Effect of Silicon.—G. Landwehr. (*Z. angew. Phys.*, July 1962, Vol. 14, No. 7, pp. 430–434.) An interpretation is given of the piezoresistance effect in Ge and Si, and the design and operation of a pressure transducer are described which is based on the longitudinal piezoresistance effect in Si.

537.311.33: 546.28: 538.614 **4120**

Faraday Rotation near the Band Edge of Silicon.—H. Piller & R. F. Potter. (*Phys. Rev. Lett.*, 1st Sept. 1962, Vol. 9, No. 5, pp. 203–205.) A report is given on observations of Faraday rotation phenomena when intrinsic Si is irradiated with polarized infrared radiation.

537.311.33: 546.28: 539.23 **4121**

Defects in Vapour-Grown Silicon Layers.—K. O. Batsford & D. J. D. Thomas. (*Solid-State Electronics*, Sept. Oct. 1962, Vol. 5, pp. 353–354.) Equilateral line etch figures observed in (111) surfaces during etching are discussed and reasons for their formation are suggested.

537.311.33: 546.28: 539.23 **4122**

Epitaxial Silicon Thin Films.—K. J. Miller, R. C. Manz & M. J. Grieco. (*J. electrochem. Soc.*, July 1962, Vol. 109, No. 7, pp. 643–645.) A study of thin-film growth by H_2 reduction of $SiCl_4$ shows that constant deposition temperature provides a considerable degree of run-to-run thickness reproducibility. Experimental details are given.

537.311.33: 546.289 **4123**

Investigation of some Uncommon Surface Treatments on Germanium.—W. A. Albers, Jr. & A. M. Rickel. (*J. electrochem. Soc.*, July 1962, Vol. 109, No. 7, pp. 582–588.) Simultaneous measurements of the change in a.c. field-effect conductivity and the surface recombination velocity as functions of surface potential were made during treatment. The sensitivity of the surface-state parameters to variations in ambient atmosphere was also observed.

537.311.33: 546.289 **4124**

Measurement of the Impurity Distribution in Diffused Layers in Germanium.—E. S. Schlegel & D. P. Sanders. (*Proc. Inst. Radio Engrs*, Sept. 1962, Vol. 50, No. 9, pp. 1987–1988.) The two techniques described are based on the measurement of 'punch-through' voltages as a function of the position of the emitter in the diffused layer with respect to a fixed collector electrode outside the layer.

537.311.33: 546.289 **4125**

Measurement of an Inhomogeneous Distribution of Recombination Centres in Germanium with the Aid of Photo-conduction and the Photo-magneto-electric Effect.—K. Thiessen & H. Hornung. (*Physica status solidi*, 1962, Vol. 2, No. 9, pp. 1158–1164. In German.) The method is used to show that the distribution of recombination centres is different from that of impurity centres introduced by doping.

537.311.33: 546.289 **4126**

The Effect of Tensile Stress on Impurity Conduction in *n*-Type Germanium.—M. Nakamura & W. Sasaki. (*J. phys. Soc. Japan*, Aug. 1962, Vol. 17, No. 8, pp. 1311–1312.) Discussion of experimental results for the case of high and intermediate concentrations of impurities.

537.311.33: 546.289 **4127**

Hysteresis in the Large-Signal Field Effect in Semiconductor Surfaces.—D. R. Frankl. (*J. electrochem. Soc.*, July 1962, Vol. 109, No. 7, pp. 608–611.) Experimental results for Ge and a simple theoretical treatment are presented.

537.311.33: 546.289: 546.681'19 **4128**

Experiments on Ge-GaAs Heterojunctions.—R. L. Anderson. (*Solid-State Electronics*, Sept./Oct. 1962, Vol. 5, pp. 341–351.)

537.311.33: 546.431'824-31 **4129**

On Very-Low-Mobility Carriers.—R. H. Tredgold. (*Proc. phys. Soc.*, 1st Sept. 1962, Vol. 80, No. 515, pp. 807–810.) An expression for the mobility of carriers in semiconductors such as $BaTiO_3$ [*J. chem. Phys.*, 15th May 1962, Vol. 36, No. 10, pp. 2640–2643 (Keller & Rast)] is based on faulty mathematics. By introducing certain valid assumptions a simpler expression is obtained showing that mobility always increases with temperature.

537.311.33: 546.48'86 **4130**

The Preparation and Electrical and Optical Properties of Cadmium Antimonide.—W. Giriat, Z. Miguła & A. Sikorski. (*Acta phys. polon.*, 1961, Vol. 20, No. 11, pp. 919–925.) The conductivity, Hall coefficient and variation of resistivity in a magnetic field were measured over the temperature range 78–370°K.

537.311.33: 546.681'18 **4131**

Charge Multiplication in GaP *p-n* Junctions.—R. A. Logan & A. G. Chynoweth. (*J. appl. Phys.*, May 1962, Vol. 33, No. 5, pp. 1649–1654.) Charge multiplication arising from carriers injected into *p-n* junctions in GaP has been studied as a function of applied bias. The carrier ionization rate as a function of field has been determined.

537.311.33: 546.681'18 **4132**

Light Emission from Forward-Biased *p-n* Junctions in Gallium Phosphide.—M. Gershenzon & R. M. Mikulyak. (*Solid-State Electronics*, Sept. Oct. 1962, Vol. 5, pp. 313–329.) Deep recombination centres in single crystals of GaP (*a*) as grown and (*b*) uniformly doped, have been studied by Hall effect, photoluminescence and absorption spectra measurements.

537.311.33: 546.682.31 **4133**

Electrical Properties of Single Crystals of Indium Oxide.—R. L. Weiher. (*J. appl. Phys.*, Sept. 1962, Vol. 33 No. 9, pp. 2834–2839.) In_2O_3 was found to be an *n*-type semiconductor over a wide temperature range. The electrical conductivity at room temperature is of the order of 10 mhos cm, and the mobility approximately 160 cm² V.sec.

537.311.33: 546.682'86 **4134**

Quantum Efficiency in InSb.—A. R. Beattie. (*J. Phys. Chem. Solids*, Aug. 1962, Vol. 23, pp. 1049–1056.) Calculations are made for parabolic bands, and for Kane's calculated band structure (3156 of 1958), assuming the overlap integrals of Bloch wave-functions to be constant. The second case is also examined using a more precise approximation to these integrals. The results are relatively insensitive to the band structure, and in agreement with experiment.

537.311.33: 546.682'86 **4135**

Significance of Crystallographic Polarity in the Fabrication of Junctions in InSb.—M. T. Minamoto. (*J. appl. Phys.*, May 1962, Vol. 33, No. 5, pp. 1826–1829.) To ensure optimum quality account must be taken of crystallographic polarity in using III-V compounds for the preparation of *p-n* junction devices.

537.311.33: 546.742-31 **4136**

Mechanical Losses in Li-Doped NiO Semiconductors.—S. van Houten. (*J. Phys. Chem. Solids*, Aug. 1962, Vol. 23, pp. 1045–1048.) The results are interpreted on the basis of a model in which the charge carriers are trapped at the Ni ions, and need an activation energy to jump to a neighbouring ion. The activation energy found agrees with that obtained from resistivity measurements.

537.311.33: 621.317.3 **4137**

The Measurement of Very Short Carrier Lifetimes in Semiconductors.—R. Bäuerlein. (*Z. angew. Phys.*, July 1962, Vol. 14, No. 7, pp. 408–412.) A pulsed 500-keV electron source is described with switching time $< 10^{-9}$s; this can be used in conjunction with an oscillograph to measure lifetimes of the same order of duration.

537.312.62: 539.23 **4138**

Critical-Field Measurements of Thin Superconducting Sn Films.—R. H. Blumberg. (*J. appl. Phys.*, May 1962, Vol. 33, No. 5, pp. 1822–1826.)

538.221 **4139**

The Characteristics of Ferromagnetic Materials in the Rayleigh Domain.—W. Hampe. (*Z. angew. Phys.*, Aug. 1962, Vol. 14, No. 8, pp. 498–506.) The characteristics of various types of ferromagnetic material are discussed with reference to Néel's interpretation of Rayleigh's law. Materials with perminvar- and isoperm-type loops do not conform to Néel's theory.

538.221 **4140**

Spin Waves in Ferromagnetic Metals.—D. M. Edwards. (*Proc. roy. Soc. A*, 25th Sept. 1962, Vol. 269, No. 1338, pp. 338–351.) A qualitative discussion is given of the low-lying states of a ferromagnetic metal and the consequent low-temperature thermodynamic properties of the system.

538.221 **4141**
Determination of the Constants *F* and *G* of the Uniaxial Induced Anisotropy at Finite Field Strengths.—R. Perthel. (*Physica status solidi*, 1962, Vol. 2, No. 9, pp. 1169–1174. In German.)

538.221 : 539.23 **4142**
Magnetic Films: Nucleation, Wall Motion, and Domain Morphology.—F. Schuler. (*J. appl. Phys.*, May 1962, Vol. 33, No. 5, pp. 1845–1850.) Report on measurements of magnetization reversal in thin Fe-Ne films.

538.221 : 539.23 **4143**
Processes in the Quasi-Static Magnetization of Thin Films.—W. Metzdorf. (*Z. angew. Phys.*, July 1962, Vol. 14, No. 7, pp. 412–424.) Various types of domain structure formed in permalloy films are illustrated and discussed.

538.221 : 539.23 **4144**
The Spontaneous Character of the Time-Variable Induced Anisotropy of Ferromagnetic Thin Films.—W. Schüppel. (*Physica status solidi*, 1962, Vol. 2, No. 9, pp. 1175–1180. In German.) Investigations were carried out on vapour-deposited Co films. The results obtained support the hypothesis of the spontaneous nature of the induced anisotropy.

538.221 : 539.23 : 538.569.4 **4145**
Dynamic Pinning in Thin-Film Spin-Wave Resonance.—P. E. Wigen, C. F. Kooi, M. R. Shanabarger & T. D. Rossing. (*Phys. Rev. Lett.*, 1st Sept. 1962, Vol. 9, No. 5, pp. 206–208.) Observations of spin-wave resonance in thin films indicate that the surface spin pinning can be explained by assuming that there exists on the film a thin surface layer in which the magnetization differs from that in the body of the film.

538.221 : 621.318.124 **4146**
Preparation of Single-Crystal Cobalt Ferrites from the Melt.—F. H. Horn. (*J. appl. Phys.*, Sept. 1962, Vol. 33, No. 9, pp. 2832–2834.) A two-step procedure is described.

538.221 : 621.318.134 **4147**
Phase Shift in Ferrites at High Power.—K. Kalikstein, N. Cooper & J. Troy. (*Proc. Inst. Radio Engrs*, Sept. 1962, Vol. 50, No. 9, p. 1989.) The technique described is used to minimize or eliminate thermal effects in the measurement of the phase shift in ferrites. Results obtained indicate that the phase change is practically independent of power level.

538.221 : 621.318.134 **4148**
Kinetics of Normal Crystal Growth in Polycrystalline Ferrites.—M. Paulus. (*Physica status solidi*, 1962, Vol. 2, No. 9, pp. 1181–1194. In French.) Crystal growth within polycrystalline aggregates of Mn-Zn and Ni-Zn ferrites is investigated; the speed of growth is approximately independent of composition but is affected by the conditions of the annealing atmosphere.

538.221 : 621.318.134 **4149**
Ferromagnetic Resonance in Polycrystalline Ferrites with Hexagonal Anisotropy.—K. A. Hempel. (*Z. angew. Phys.*, Aug. 1962, Vol. 14, No. 8, pp. 488–495.) Report of measurements on Ba ferrites at 9·65 and 23·89 Gc/s.

538.221 : 621.318.134 **4150**
The Spontaneous Isoperm Loop of Manganese-Zinc Ferrites.—M. Kornetzki. (*Z. angew. Phys.*, July 1962, Vol. 14, No. 7, pp. 424–427.) A model of this type of ferrite is proposed. See also 1944 of 1961 (Kornetzki et al.).

538.221 : 621.318.134 **4151**
The Temperature Dependence of the Isoperm Effect of Manganese-Zinc Ferrites.—E. Röss. (*Z. angew. Phys.*, Aug. 1962, Vol. 14, No. 8, pp. 495–498.) Hysteresis loops obtained at various temperatures are reproduced and the changes in shape are discussed with reference to the model proposed by Kornetzki (4150 above).

538.221 : 621.318.134 **4152**
The Properties of Mixed Yttrium-Gadolinium Garnets.—A. Vassiliev, J. Nicolas & M. Hildebrandt. (*C. R. Acad. Sci., Paris*, 24th April 1961, Vol. 252, No. 17, pp. 2529–2531.)

538.221 : 621.318.134 : 538.569.4 **4153**
Spin-Wave Instability at Large Precession Angles.—E. Schlömann. (*J. appl. Phys.*, Sept. 1962, Vol. 33, No. 9, pp. 2822–2824.) Second-order instability is investigated for the case of thin disks of ferrimagnetic material.

538.222 : 621.375.9 : 538.569.4 **4154**
Zinc Tungstates for Microwave Maser Applications.—L. G. Van Uitert & S. Preziosi. (*J. appl. Phys.*, Sept. 1962, Vol. 33, No. 9, pp. 2908–2909.) Large single crystals can be prepared by the Czochralski technique.

539.23 **4155**
The Deposition of Mixed Oxide Layers by Reactive Sputtering.—W. P. Bickley & D. S. Campbell. (*Le Vide*, May/June 1962, Vol. 17, No. 99, pp. 214–221. In French and English.) The structure and electrical properties of specimen films of mixed oxides of Pb and Ti sputtered under different conditions have been investigated. Experimental details are given and the effects of varying the Pb/Ti ratio in the cathode and annealing the films are illustrated by graphs.

539.23 **4156**
A New Cathode Sputtering Method using a Ring Discharge Plasma.—H. Gawehn. (*Z. angew. Phys.*, Aug. 1962, Vol. 14, No. 8, pp. 458–462.) The properties of the thin films produced by the method described are compared with those of vapour-deposited films.

539.23 : 537.533.9 **4157**
Conducting Thin Films Formed by Electron Bombardment of Substrate.—R. W. Christy. (*J. appl. Phys.*, May 1962, Vol. 33, No. 5, pp. 1884–1888.) $SnCl_2$ has been decomposed to metallic tin, and tetrabutyl tin partially decomposed by a 200-eV 1-mA/cm² electron beam. The technique should be widely applicable.

MATHEMATICS

512.37 : 621.3.011 **4158**
The Use of Bounds on Electrical Problems involving Anisotropic Material.—G. Power & H. L. W. Jackson. (*Acta phys. austriaca*, June 1962, Vol. 15, No. 3, pp. 217–227. In English.) Applications of the approximation theory discussed include the solution of problems on two-dimensional resistances and capacitances.

517.9 **4159**
The Theory of the Differential Equation of the Parabolic Cylinder.—J. Bauer. (*Acta phys. austriaca*, June 1962, Vol. 15, No. 3, pp. 228–243. In German.) The differential equation is treated as a special case of the Laplace equation.

517.942.82 : 621.374 **4160**
Some Examples on the Application of Difference Equations and the Discrete Laplace Transformation to Pulse Techniques.—A. Darré. (*Frequenz*, July 1962, Vol. 16, No. 7, pp. 262–270.) The examples given include a rectifier circuit, pulse generator with capacitive and transformer-type output coupling, and a low-pass filter.

518.4 : 621.372.6 **4161**
Camouflaging Electrical 1-Networks as Graphs.—G. Kron. (*Quart. appl. Math.*, July 1962, Vol. 20, No. 2, pp. 161–174.)

519.2 : 621.391.81 **4162**
Some Statistical Theory for the Analysis of Radio Propagation Data.—Siddiqui. (See 4183.)

MEASUREMENTS AND TEST GEAR

621.317.3.029.6 **4163**
Conference on Microwave Measurement Techniques.—(*Proc. Instn elect. Engrs*, Part B, 1962, Vol. 109, Supplement No. 23, pp. 639–880.) The text is given of the papers presented at an I.E.E. Conference held in London, September 1961.

621.317.335.2 : 621.382.23 **4164**
Three Ways to measure Varactors of the Future.—F. P. Chiffy & J. L. Gurley, Jr. (*Electronics*, 7th Sept. 1962, Vol. 35, No. 36, p. 49.) The range and accuracy of *Q*-meter, a.c. bridge and *R-X*-meter methods are compared.

621.317.412 **4165**
Metal Cryostat for Measurements of Magnetic Susceptibility in the Temperature Range 4·3 to 300°K.—K. H. Hellwege, U. Johnson & B. Schneider. (*Z. angew. Phys.*, Aug. 1962, Vol. 14, No. 8, pp. 481–484.)

621.317.7.029.65 **4166**
A 1962 Review of Millimetre-Wave Instrumentation.—L. L. Bertan. (*Micro-*

wave J., Aug. 1962, Vol. 5, No. 8, pp. 69–75.) A paper presented at the I.R.E. International Convention 1962, describing signal sources, transmission lines and components.

621.317.73: 537.311.33 **4167**

Minimal Maintenance Probe for Precise Resistivity Measurement of Semiconductors.—C. L. Paulnack & N. J. Chaplin. (*Rev. sci. Instrum.*, Aug. 1962, Vol. 33, No. 8, pp. 873–875.) A four-point probe design is described which simplifies semiconductor measurements.

621.317.733: 621.396.677.3 **4168**

Antenna Mutual-Impedance Bridge.—W. E. Rupp. (*Microwave J.*, Aug. 1962, Vol. 5, No. 8, pp. 95–98.) A description of the operation and calibration procedure with a note on the construction of an L-band instrument for measurements on large aerial arrays.

621.317.733.025 **4169**

Beat-Frequency Bridge for Large-Signal Field Effect.—D. Gerlich. (*J. appl. Phys.*, May 1962, Vol. 33, No. 5, pp. 1815–1816.) An adaptation of the conventional balanced-bridge method is described and field-effect measurements on low-resistivity Ge and GaAs are reported.

621.317.74: 621.372.823 **4170**

Measurements on Circular Electric Waveguide Characteristics by the Resonant-Cavity Method.—M. Shimba. (*Rev. elect. Commun. Lab., Japan*, May/June 1962, Vol. 10, Nos. 5/6, pp. 248–260.) Description of measuring equipment for the study of the characteristics of helix and solid copper waveguides based on *Q*-factor measurements of resonant cavities formed by short-circuiting the waveguide.

621.317.742.029.65 **4171**

Measuring Standing Wave Ratio by Directional Coupler and Phase Shifter in the Millimetre Wave Range.—M. A. Grigor'ev, L. I. Kats & Sh. E. Tsimring. (*Izv. vyssh. uch. Zav., Radiotekhnika*, Jan./Feb. 1962, Vol. 5, No. 1, pp. 47–50.) The principle of the method is described with a note on the circuit arrangement in which the phase shifter is used to reduce the noise due to insufficient directivity of the coupler. Results are compared with those obtained using a stationary-probe method.

621.317.76.029.65 **4172**

New Wavemeter for Millimetre Wavelengths.—R. W. Zimmerer. (*Rev. sci. Instrum.*, Aug. 1962, Vol. 33, No. 8, pp. 858–859.) A note on the design and operation of a simple wavemeter using a confocal resonator [see e.g. 2174 of 1961 (Boyd & Gordon)].

621.317.79.029.64 **4173**

Microwave Interferometer for the Measurement of Electron Density in Ionized Gases.—J. Bliaux & M. Ray. (*Onde élect.*, July/Aug. 1962, Vol. 42, Nos. 424/425, pp. 594–602.) Electron density is measured in terms of the phase shift of a 9·2-Gc/s signal. An accuracy within a few degrees is possible with a pass-band of 100 kc/s.

OTHER APPLICATIONS OF RADIO AND ELECTRONICS

621.362: 537.227 **4174**

Application of a Ferroelectric Material in an Energy Conversion Device.—J. D. Childress. (*J. appl. Phys.*, May 1962, Vol. 33, No. 5, pp. 1793–1798.) Analysis of the operation of the thermodielectric converter [e.g. 2746 of 1961 (Clingman & Moore)].

621.362: 537.32 **4175**

Thermopile Solar Converters.—Nguyen Thien-Chi. (*Onde élect.*, June 1962, Vol. 42, No. 423, pp. 554–562.) A practical and theoretical treatment of the principles of construction of thermoelectric generators and the optimum operating characteristics.

621.362: 621.383.5 **4176**

Thermo-photoelectric Energy Conversion.—A. Fortini. (*Onde élect.*, June 1962, Vol. 42, No. 423, pp. 530–540.) A simplified model is used to calculate the conversion efficiency of a cooled *p-i-n* structure irradiated by a local source. The operation of a practical device is considered and the potential advantages over the solar cell are noted.

621.384.6 **4177**

High-Voltage Acceleration Tubes utilizing Inclined-Field Principles.—R. J. Van de Graaff, P. H. Rose & A. B. Wittkower. (*Nature, Lond.*, 29th Sept. 1962, Vol. 195, No. 4848, pp. 1292–1293.) The performance of three large-aperture tubes which have been developed to avoid the 'total-voltage effect' is described.

621.385.833: 537.311.33: 546.28 **4178**

Experimental Determination of the Current-Density/Electric-Field Relationship of Silicon Field Emitters.—R. L. Perry. (*J. appl. Phys.*, May 1962, Vol. 33, No. 5, pp. 1875–1883.) Further results of investigations of the field-emission characteristics from Si cold cathodes in a field-emission projection microscope are presented. See 1561 of 1961.

621.385.833: 621.317.729.1 **4179**

A Study of some Properties of an Electrostatic Quadrupole Lens using an Automatic Electron Trajectory Tracer.—B. C. Gregory & K. F. Sander. (*J. Electronics Control*, Aug. 1962, Vol. 13, No. 2, pp. 123–136.)

621.387.462 **4180**

Calculation of the Radiation-Excited Conductivity Pulses of a Crystal Counter, and Consideration of the Field Distribution Disturbed by Space Charges.—C. R. Vidal & I. Ruge. (*Z. angew. Phys.*, July 1962, Vol. 14, No. 7, pp. 389–394.)

PROPAGATION OF WAVES

621.371 **4181**

Wave Propagation Around a Curved Boundary which Contains an Obstacle.—J. R. Wait. (*Canad. J. Phys.*, Aug. 1962, Vol. 40, No. 8, pp. 1010–1016.) An approximate solution is obtained by combining the rigorous theory of diffraction by a sphere and the approximate Kirchhoff diffraction theory for black screens. The application to ground-wave propagation is briefly indicated.

621.391.81 **4182**

Influence of Ground Conductivity on Radio Wave Propagation Curves.—M. Argirović. (*Telekomunikacije*, July 1961, Vol. 10, No. 3, pp. 1–7.) Expressions are derived for calculating the electric field in wave propagation through homogeneous ground. The surface wave propagation for frequencies below 0·5 Mc/s, was found to be comparable to the underground wave propagation.

621.391.81: 519.2 **4183**

Some Statistical Theory for the Analysis of Radio Propagation Data.—M. M. Siddiqui. (*J. Res. nat. Bur. Stand.*, Sept./Oct. 1962, Vol. 66D, No. 5, pp. 571–580.) Characteristics of stationary processes such as covariance and spectral density functions are developed, and examples are given to illustrate the theory.

621.391.812.5: 523.5 **4184**

High-Resolution Pulse Measurements of Meteor-Burst Propagation at 41 Mc/s over a 1 295-km Path.—R. J. Carpenter & G. R. Ochs. (*J. Res. nat. Bur. Stand.*, May/June 1962, Vol. 66D, No. 3, pp. 249–257.) Observations on reflections from meteor trails of 3μs pulses show no multipath components from single trails. Pulse spreads > 10μs were occasionally observed.

621.391.812.6 **4185**

On the Role of the Process of Reflection in Radio Wave Propagation.—F. du Castel, P. Misme, A. Spizzichino & J. Voge. (*J. Res. nat. Bur. Stand.*, May/June 1962, Vol. 66D, No. 3, pp. 273–284.) A study of the process of reflection from irregular stratified media. Expressions are derived for variation with frequency of total power reflected. Examples considered are trans-horizon and sporadic-E propagation and propagation over an irregular ground surface.

621.391.812.62 **4186**

Correlation between Hourly Median Scattered Signals and Simple Refractivity Parameters.—A. S. Dennis. (*J. Res. nat. Bur. Stand.*, May/June 1962, Vol. 66D, No. 3, pp. 285–289.) Refractivity profiles, obtained from radiosonde data, are found to give correlation with signal strength measured over two tropospheric scatter links of 85 and 300 miles.

621.391.812.623 **4187**

Propagation of Plane Electromagnetic Waves Past a Shoreline.—J. Bazer

& S. N. Karp. (*J. Res. nat. Bur. Stand.*, May/June 1962, Vol. 66D, No. 3, pp. 319–334.) A recent version of a report first issued in 1952 giving a theoretical treatment of the diffraction of waves at a shore line. The extension of the method to the investigation of coastal refraction is discussed.

621.391.812.624 **4188**

Mid-Field Forward Scattering.—C. I. Beard, T. H. Kays & V. Twersky. (*J. appl. Phys.*, Sept. 1962, Vol. 33, No. 9, pp. 2851–2867.) Experimental and theoretical results are given for e.m. forward scattering by spheres with radius large compared to λ, and with index of refraction close to unity.

621.391.812.63 **4189**

The Cross-Section for Scattering of Electromagnetic Waves from an Ionized Gas in Thermal Nonequilibrium.—J. Renau. (*J. geophys. Res.*, Aug. 1962, Vol. 67, No. 9, pp. 3624–3626.) The results of ionospheric experiments are considered in terms of theoretical estimates of the scattering cross-section. See also 1021 of 1961.

621.391.812.63 **4190**

A Solution to the Boundary-Value Problem of Radio Wave Propagation around the Earth allowing for the Main Geophysical Factors.—P. E. Krasnushkin. (*Dokl. Ak. Nauk S.S.S.R.*, 11th June 1961, Vol. 138, No. 5, pp. 1055–1058.)

621.391.812.63 **4191**

Ionospheric Irregularities and Long-Distance Radio Propagation.—H. A. Whale. (*J. Res. nat. Bur. Stand.*, May/June 1962, Vol. 66D, No. 3, pp. 265–272.) The variations of the bearing of s.w. signals over long ranges are considered, with special reference to day-to-day fluctuations about the mean direction. The importance of these fluctuations in the design of receiving aerials is discussed.

621.391.812.63 **4192**

Increase in Maximum Usable Frequency for Two-Hop Transatlantic Propagation due to Horizontal Gradients.—H. P. Williams. (*Nature, Lond.*, 20th Oct. 1962, Vol. 196, No. 4851, pp. 256–258.) Oblique-incidence recordings on a 5 600-km path show a strong correlation between M.U.F. increases and horizontal ionization gradients.

621.391.812.63: 551.507.362.2 **4193**

Propagation of Spherical Waves through an Ionosphere containing Anisotropic Irregularities.—K. C. Yeh. (*J. Res. nat. Bur. Stand.*, Sept./Oct. 1962, Vol. 66D, No. 5, pp. 621–636.) The theory given is applied to the problem of scintillation dependence on the height of the transmitter above a slab of irregularities. The scintillation index should be relatively insensitive to the zenith angle of the position of a satellite for a temperate latitude station; this agrees with preliminary observations.

621.391.812.63: 551.594.5 **4194**

Auroral Absorption of Radio Signals.—C. W. Gartlein & G. Sprague. (*J. geophys. Res.*, Aug. 1962, Vol. 67, No. 9, pp. 3393–3396.) A study of auroral and radio transmission data indicates that when a radio path goes within 2° of latitude of an aurora, the signal deteriorates.

621.391.812.63.029.42 **4195**

Schumann Resonances of the Earth-Ionosphere Cavity: Extremely-Low-Frequency Reception at Kingston, R.I.—C. Polk & F. Fitchen. (*J. Res. nat. Bur. Stand.*, May/June 1962, Vol. 66D, No. 3, pp. 313–318.) Further confirmation of the cavity resonance effect at 7–10 c/s originally suggested by Schumann (3596 of 1953) and detected experimentally by König (see 3519 of 1960).

621.391.812.63.029.45 **4196**

Diurnal and Seasonal Variations of the Distant Field of Long Radio Waves.—P. E. Krasnushkin. (*Dokl. Ak. Nauk S.S.S.R.*, 1st Oct. 1961, Vol. 140, No. 4, pp. 783–786.) Graphs show the diurnal amplitude and phase variations in Great Britain, U.S.A. and U.S.S.R. and maps indicate the ionization in the northern hemisphere in summer and winter months.

RECEPTION

621.376.33 **4197**

Reaction of an Inertial System to Zero Beats.—M. I. Dorman. (*Radiotekhnika, Mosk.*, Jan. 1962, Vol. 17, No. 1, pp. 13–21.) An analysis of the response of (*a*) a single-stage low-pass *RC* filter, and (*b*) a single resonant circuit to a heterodyned f.m. signal.

621.391.8: 621.396.67 **4198**

On the Reception of Quasi-Monochromatic, Partially Polarized Radio Waves.—Ko. (See 3930.)

621.391.812.3: 621.376 **4199**

Effects of Fading on Quadrature Reception of Orthogonal Signals.—G. Lieberman. (*RCA Rev.*, Sept. 1962, Vol. 23, No. 3, pp. 353–395.) An analysis of the effects of fading, frequency instability and noise is given. See also 677 of February.

621.391.812.621 **4200**

A Comparative Study of the Correlation of Seasonal and Diurnal Cycles of Transhorizon Radio Transmission Loss and Surface Refractivity.—B. R. Bean, L. Fehlhaber & J. Grosskopf. (*J. Res. nat. Bur. Stand.*, Sept./Oct. 1962, Vol. 66D, No. 5, pp. 593–599.) Correlations were examined for results observed on 34 U.S. and 9 German radio paths. The surface refractivity may provide as useful a prediction of diurnal and seasonal variations of transmission loss as radio measurements made over the actual radio path.

621.391.812.624 **4201**

Statistical Distribution of the Amplitude and Phase of a Multiply Scattered Field.—P. Beckmann. (*J. Res. nat. Bur. Stand.*, May/June 1962, Vol. 66D, No. 3, pp. 231–240.) Derivation of the probable distribution of the amplitude and phase of a large number of two-dimensional vectors under specified ground conditions.

621.391.812.63 **4202**

Observations of Radio-Wave Phase Characteristics on a High-Frequency Auroral Path.—J. W. Koch & W. M. Beery. (*J. Res. nat. Bur. Stand.*, May/June 1962, Vol. 66D, No. 3, pp. 291–296.) Measurements were made of the phase stability of different signals over periods of a few milliseconds at approximately 10, 15 and 19 Mc/s. No significant difference between c.w. and pulse signals was found.

621.396.621.53: 621.391.63 **4203**

Heterodyne Receivers for R.F.-Modulated Light Beams.—D. J. Blattner & F. Sterzer. (*RCA Rev.*, Sept. 1962, Vol. 23, No. 3, pp. 407–412.) The frequency of amplitude or phase modulation on a light beam is shifted by heterodyning with an r.f. oscillator in an electro-optic modulator [see e.g. 2257 of July (Blumenthal)]. Expressions derived for conversion loss are in good agreement with measurements made.

621.396.662 **4204**

Designing a Phase-Locked Loop as a Doppler Tracker.—C. S. Weaver. (*Proc. Inst. Radio Engrs*, Sept. 1962, Vol. 50, No. 9, p. 1992.) The design procedure for a tracking filter is given.

STATIONS AND COMMUNICATION SYSTEMS

621.391 **4205**

Quantum Effects in Communications Systems.—J. P. Gordon. (*Proc. Inst. Radio Engrs*, Sept. 1962, Vol. 50, No. 9, pp. 1898–1908.) The information capacity and efficiency of various communication systems are considered taking into account quantum effects and varying power levels.

621.395 + 621.397.13 **4206**

The Gain in Intelligibility with 'Videophony'.—O. Brosze, K. O. Schmidt & A. Schmoldt. (*Nachrichtentech. Z.*, July 1962, Vol. 15, No. 7, pp. 349–352.) Results of intelligibility measurements on systems of telephony with television show that the visual information transmitted simultaneously with the sound produces an improvement in intelligibility particularly in the presence of noise.

621.396.216 **4207**

A Method for Obtaining Compatible Single-Sideband Modulation.—T. J. van Kessel, F. L. H. M. Stumpers & J. M. A. Uyen: L. R. Kahn. (*Proc. Inst. Radio Engrs*, Sept. 1962, Vol. 50, No. 9, pp. 1998–1999.) Comment on 290 of January and author's reply. See also 3151 of September (van Kessel et al.).

621.396.43: 551.507.362.2 **4208**

Coherent F.D.M./F.M. Telephone Communication.—J. A. Develet, Jr. (*Proc. Inst. Radio Engrs*, Sept. 1962, Vol. 50, No. 9, pp. 1957–1966.) An analysis of a satellite repeater system for telephone communication based on a frequency-modulated carrier with frequency-division multiplex of the telephone channels, and incorporating coherent demodulation techniques in the receiver. Sensitivity, bandwidth, and channel quality are discussed in terms of C.C.I.R. standards.

621.396.43:551.507.362.2:621.396.67 **4209**

Scatterer Echo Area Enhancement.—J. L. Ryerson. (*Proc. Inst. Radio Engrs*, Sept. 1962, Vol. 50, No. 9, pp. 1979–1980.) To enhance the echo area of a satellite scatterer, a Van Atta array could be used with amplifiers inserted in the lines connecting the array elements. The realization of such a system is discussed.

621.396.65 **4210**

Tests on Passive Repeaters used in Microwave Radio Links.—C. Colavito, G. D'Auria & B. Peroni. (*Alta Frequenza*, May 1962, Vol. 31, No. 5, pp. 271–284. In English.) Report of experimental investigations on a 7-Mc/s radio link. Absolute and relative measurements of efficiency were carried out by means of 9350-Mc/s radar equipment and a balloon-borne metallized sphere as reference scattering obstacle. The re-radiation diagram of the repeater mirror is calculated.

621.396.74 **4211**

Frequency Plan for 6-Gc/s Microwave Systems.—B. R. Hallford. (*Commun. & Electronics*, July 1962, No. 61, pp. 161–166.) Frequency spectrum conservation and the prevention of interference among 6-Gc/s microwave systems are shown to be possible when a modified TH-system frequency plan is used (see e.g. 1043 of March).

SUBSIDIARY APPARATUS

621.311.69:621.383.5 **4212**

Photovoltaic Solar Cells.—F. Desvignes. (*Onde élect.*, June 1962, Vol. 42, No. 423, pp. 563–575.) A detailed treatment of the properties and applications of photocells. 93 references.

TELEVISION AND PHOTOTELEGRAPHY

621.397.6 **4213**

Problems of Television Relay Reception.—W. Strössenreuther & H. C. Höring. (*Radio Mentor*, May–July 1962, Vol. 28, Nos. 5–7, pp. 404–408, 510–515 & 598–601.)

Part 1: General Problems of Reception (pp. 404–408).

Part 2: Receiver Design (pp. 510–515).

Part 3: A Television Image Relay Receiver (pp. 598–601.)

621.397.62 **4214**

The Basic Principles of Optical Line Suppression.—H. Schulz. (*Radio Mentor*, July 1962, Vol. 28, No. 7, pp. 593–597.) Description of the design of a grooved plate which, placed in front of the screen of a television picture tube, diffuses the line structure. The advantages of this system over others, particularly with regard to cost, are outlined.

621.397.63:621.395.625.3 **4215**

TV Tape Time Stability.—A. Harris. (*Wireless World*, Nov. 1962, Vol. 68, No. 11, pp. 516–520.) Types and causes of timing errors in video tape are described, and methods of minimizing and eliminating these errors are discussed.

VALVES AND THERMIONICS

621.382 + 621.385.1 **4216**

Some Generalities of the Transit-Time Mode for Two-Barrier Devices.—J. Lindmayer & C. Wrigley. (*J. Electronics Control*, Aug. 1962, Vol. 13, No. 2, pp. 137–158.) A generalized analysis is given of a class of two-barrier devices having injection and collection electrodes, and in which the injected current wave gives rise to negative and positive resistances, inductances and capacitances. In particular, the frequency range of negative resistance is discussed, with reference to thermionic valves, transistors and metal/interface amplifiers.

621.382 **4217**

An Investigation of Surface States at a Silicon/Silicon-Oxide Interface employing Metal/Oxide Silicon Diodes.—L. M. Terman. (*Solid-State Electronics*, Sept./Oct. 1962, Vol. 5, pp. 285–299.) A new solid-state device, the M-O-S diode, of which an oxidized silicon surface is an integral part, is introduced, and a theory for its operation in the absence of surface states is obtained. The capacitance of this device may be considerably more voltage-sensitive than that of a *p-n* junction.

621.382:539.23 **4218**

Shot Noise in Thin-Film Transistors.—A. van der Ziel. (*Proc. Inst. Radio Engrs*, Sept. 1962, Vol. 50, No. 9, pp. 1985–1986.) Shot-noise theory is adapted to thin-film transistor-type devices so that standard procedures for calculating noise resistance and noise figure can be applied.

621.382:621.375.9 **4219**

Experiments on the Metal-Interface Amplifier.—J. M. Lavine & A. A. Iannini. (*Solid-State Electronics*, Sept./Oct. 1962, Vol. 5, pp. 273–283.) A series of experiments is reported on units comprising an Al_2O_3 film on Al deposited on Ge, with a thick Au emitter. *I/V* characteristics of the Au-Al_2O_3-Al, Al-Ge and Au-Ge structures are reproduced. A maximum power gain of 100 was measured at room temperature at a frequency of 1 kc/s.

621.382.032.27 **4220**

On the Static Characteristics of High-Low Junction Devices.—R. W. Lade & A. G. Jordan. (*J. Electronics Control*, July 1962, Vol. 13, No. 1, pp. 23–34.) A static analysis of the RνNR structure shows gross deviations from the expected ohmic behaviour. Assuming the total current density to be a known solenoidal vector the excess-carrier concentration and the terminal voltage are calculated. Experimental results are given verifying the theory.

621.382.23 **4221**

Indium Phosphide Esaki Diodes.—C. A. Burrus. (*Solid-State Electronics*, Sept./Oct. 1962, Vol. 5, pp. 357–358.) Difficulties in the fabrication of InP diodes are described. Operation in the mm-λ region appears to be feasible.

621.382.23 **4222**

Dependence of Peak Current Density on Acceptor Concentration in Germanium Tunnel Diodes.—P. N. Butcher, K. F. Hulme & J. R. Morgan. (*Solid-State Electronics*, Sept./Oct. 1962, Vol. 5, pp. 358–360.) A note on the method of making the diodes and a comparison of theoretical and experimental results.

621.382.23:538.63 **4223**

Negative-Resistance InSb Diodes with Large Magnetic-Field Effects.—I. Melngailis & R. H. Rediker. (*J. appl. Phys.*, May 1962, Vol. 33, No. 5, pp. 1892–1893.) Sensitive magnetic switching is possible from high- to low-impedance states or vice versa. Switching times of the order of 10^{-7} s are reported.

621.382.23:621.372.6 **4224**

The Tunnel Diode as a Linear Network Element.—Sandberg. (See 3968.)

621.382.23:621.373.029.6 **4225**

Stability of Tunnel-Diode Oscillators.—F. Sterzer. (*RCA Rev.*, Sept. 1962, Vol. 23, No. 3, pp. 396–406.) Causes of oscillator frequency variations are discussed. The fractional frequency drifts can be restricted to $< 3 \times 10^{-6}$ per °C of ambient temperature change, 2×10^{-6} per mV change in d.c. supply voltage, and 1×10^{-4} for an increase in voltage s.w.r. from 1 to 2.

621.382.23:621.375.9 **4226**

Tunnel Diodes for Low-Noise Microwave Amplification.—L. D. Armstrong. (*Microwave J.*, Aug. 1962, Vol. 5, No. 8, pp. 99–102.) The relation between tunnel diode characteristics and amplifier noise figure is considered and the method of preparation and operating characteristics of GaSb diodes are given.

621.382.23.002.2 **4227**

Nomograph for the Preparation of Germanium Tunnel Diodes.—A. Schmitz. (*Solid-State Electronics*, Sept./Oct. 1962, Vol. 5, pp. 354–356.) The nomograph relates maximum alloying temperature, impurity concentration of the starting material (*p*-type Ge doped with Ga), the peak current density *J*, the specific capacitance, and the peak/valley ratio β for four different Ga concentrations.

621.382.23.002.2 **4228**

Germanium Esaki Diode by Double Alloy Method.—T. Hayashi, H. Watanabe & K. Nemoto. (*NEC Res. Developm.*, June 1962, No. 3, pp. 52–65.) Details are given of the manufacturing process and experimental results obtained. The electrical characteristics of trial diodes are reported.

621.382.233: 621.318.57 **4229**

Experimental Investigation of the Switching Mode in Two-Electrode Semiconductor Devices with Negative Resistance and *p-n-p-n*-Type Structure.—M. A. Berg & S. A. Garyainov. (*Radiotekhnika, Mosk.*, Jan. 1962, Vol. 17, No. 1, pp. 51–58.) Measurements of delay and switching time have been made on a large number of diodes. Three groups are identified and the physical processes underlying the different characteristics are discussed.

621.382.3 **4230**

The Characteristics of Transistors under Large-Signal Conditions.—R. Wiesner. (*Nachrichtentech. Z.*, July 1962, Vol. 15, No. 7, pp. 323–332.) Systematic review of the effects arising in transistors operating under large-signal drive conditions.

621.382.3 **4231**

Selection of Germanium Transistor Parameters by Control of Moisture at Low Levels within the Device Encapsulation.—R. J. Gnaedinger, Jr, S. S. Flaschen, M. A. Hall & E. J. Richez. (*J. electrochem. Soc.*, July 1962, Vol. 109, No. 7, pp. 589–595.) By controlling the partial pressure of moisture at any of various given levels within hermetically sealed transistors, it is possible to pre-select different ranges of several stabilized device parameters, such as h_{fe}, I_{CO} I_{EO} without changing the device fabrication procedure.

621.382.3: 539.12.04 **4232**

The Influence of Neutrons on Transistors, in particular, Ge Transistors.—F. Nibler. (*Z. angew. Phys.*, July 1962, Vol. 14, No. 7, pp. 394–398.) No permanent damage was caused by radiation doses up to about 10^{10} neutrons/cm^2; doses $>10^{14}$ neutrons/cm^2 destroyed the effectiveness of nearly all types of transistor tested.

621.382.3.017.7 **4233**

Heat Transfer in Transistors.—E. D. Veilleux. (*Electro-Technol.*, Sept. 1962, Vol. 70, No. 3, pp. 97–100.) The basic equations of heat transfer are given and used with test data in an attempt to reduce the number of parameters which need to be considered.

621.382.333 **4234**

Guide to Modern Junction-Transistor Types.—R. L. Pritchard. (*Electronics*, 17th Aug. 1962, Vol. 35, No. 33, pp. 46–49.) Types of transistor are classified in accordance with the method of fabrication.

621.382.333 **4235**

Transistors for Avalanche-Mode Operation.—H. W. Miller & Q. A. Kerns. (*Rev. sci. Instrum.*, Aug. 1962, Vol. 33, No. 8, pp. 877–878.) Certain types of transistor exhibit useful avalanche effects although their static characteristics are identical with transistors with no avalanche tendency.

621.382.333 **4236**

Effects in Mesa Transistors at High Current Density.—H. Rüchardt. (*Nachrichtentech. Z.*, July 1962, Vol. 15, No. 7, pp. 333–340.) The influence of the high-resistance collector region on d.c. and a.c. characteristics is examined and the advantages of epitaxial construction are discussed. A mechanism of space-charge modification is proposed to explain the effects observed.

621.382.333.3 **4237**

Degradation Mechanisms in Germanium *p-n-p* Alloy Transistors.—H. R. Wilson. (*Semiconductor Prod.*, June & July 1962, Vol. 5, Nos. 6 & 7, pp. 25–28 & 18–21.) The degradation of transistor parameters is due primarily to surface effects. Tests show that the small-signal current gain and the leakage current are the best criteria. Power-dissipation life tests tend to be more severe than temperature storage tests.

621.383.52 **4238**

Investigation of an Isolated *p-n* Junction as a Function of Received Illumination and Temperature.—G. A. Boutry & M. Robert. (*C. R. Acad. Sci., Paris*, 24th April 1961, Vol. 252, No. 17, pp. 2540–2542.) A comparison of theoretical and experimental results for a Ge photodiode at temperatures down to 150°K.

621.385.032.213.23 **4239**

Fast-Heating Thermionic Cathodes.—E. G. Dorgelo. (*Commun. & Electronics*, July 1962, No. 61, pp. 222–224.) Nickel ribbon and tungsten 'harp' cathodes with heating times <1 sec are described.

621.385.032.269.1 **4240**

Electrode Design for Axially Symmetric Electron Guns.—K. J. Harker. (*J. appl. Phys.*, May 1962, Vol. 33, No. 5, pp. 1861–1863.) Improvements in the method given in 1362 of 1961 are described.

621.385.6 **4241**

The Space-Charge-Controlled Focus of an Electron Beam.—D. L. Hollway. (*J. Brit. Instn Radio Engrs*, Sept. 1962, Vol. 24, No. 3, pp. 209–211.) Solutions of the space-charge equations governing the defocusing of electron beams having circular symmetry are tabulated. An approximation of the ratio of spot radius to initial beam radius is given, suitable for most beam design problems.

621.385.6 **4242**

Relativistic Beam-Wave Interaction.—A. J. Monk & H. J. Curnow: J. E. Rowe. (*Proc. Inst. Radio Engrs*, Sept. 1962, Vol. 50, No. 9, pp. 1978–1979.) Comment on 1761 of May and author's reply.

621.385.6 **4243**

Electron Streams in an Oscillating Electric Field.—W. Sackinger. (*J. appl. Phys.*, May 1962, Vol. 33, No. 5, pp. 1784–1786.) Exact analytic expressions are obtained for the variation of current and velocity with time at a given position.

621.385.6 **4244**

The Instability of Electron Beams in Crossed Fields in the Presence of an Obliquely Propagating Perturbation.—B. Glance & G. Mourier. (*C. R. Acad. Sci., Paris*, 24th April 1961, Vol. 252, No. 17, pp. 2532–2533.) An extension of previous work by Epsztein (2568 of 1956).

621.385.6: 537.533: 538.561 **4245**

Stimulated Emission of Bremsstrahlung.—D. Marcuse. (*Bell. Syst. tech. J.*, Sept. 1962, Vol. 41, No. 5, pp. 1557–1571.) An approximate theoretical treatment is given of the scattering of a stream of electrons by an individual ion or nucleus in the presence of a radiation field. Stimulated emission occurs if the incident electrons travel in a direction roughly parallel to the electric field vector. The possibility of constructing an oscillator or wide-band amplifier based on this principle which would not require bunched electron beams and special phase relations is noted. The effect may also account for unexplained oscillations observed in semiconductor diodes [e.g. 2009 of June (Kikuchi)].

621.385.6: 621.372.832 **4246**

Heating of Waveguide Windows as a Limit to the Output Power of Microwave Tubes.—Paschke. (See 3925.)

621.385.62: 621.317.335.3 **4247**

The Frequency and Amplitude Stability of Microwave Klystrons (particularly for Measurements of Dielectric Constant).—W. Mecke. (*Z. angew. Phys.*, July 1962, Vol. 14, No. 7, pp. 428–429.) Stability requirements and the dependence of stability on various factors are discussed.

MISCELLANEOUS

001.891: 621.396 **4248**

Radio Research 1961: The Report of the Radio Research Board and the Report of the Director of Radio Research. [Book Review]—Publishers: H.M. Stationery Office, London, 1962. 27 pp., 3s. (*Nature, Lond.*, 22nd Sept. 1962, Vol. 195, No. 4847, pp. 1160–1161.)

This issue completes the 1962 Abstracts and References supplied with *Electronic Technology* from January to September and *Industrial Electronics* from October to December. As already announced no further Abstracts will be produced.
The Index to Abstracts and References 1962 is being prepared and it is expected that it will be available in March 1963.

INDUSTRIAL ELECTRONICS

incorporating *ELECTRONIC TECHNOLOGY*

Volume 1 Number 3 December 1962

contents

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contents continued

FEATURES

OUR COVER

This shows the Park Ultrasonic Pig Grader being demonstrated in the factory of the Letchworth Bacon Co. Ltd. This instrument is designed to measure the fat and lean meat of live and dead pigs. An article describing the device and its application is included elsewhere in this issue.

Next Month

The January issue will include an article dealing with the use of radioisotopes for checking that cattle food has been properly mixed and for the measurement of bulk flow of materials. Other articles will deal with the use of ultrasonics for sensing and switching, and with a quick-acting echo depth sounder.

TO SAVE YOUR TIME

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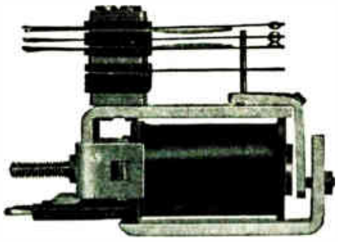
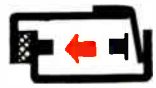
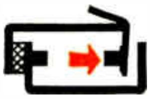
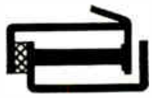
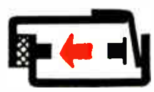
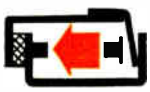
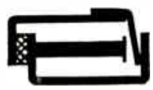


Based on the well-known Ericsson **G.P.** design, this new **L.M.C.** miniature relay is introduced to provide simple and reliable magnetic latching with extra facilities not found in remanent or mechanical latching types.  Being magnetically polarized it will not change its state unless the polarity of the energising current is correct.  A small current in the correct direction however will operate the relay  which will stay operated even when the current is disconnected.  To release, the current must be applied in the reverse direction.  No 'suicide' contacts are necessary to safeguard against relay re-operation where 'release' currents are excessive or of long duration.  The release condition is maintained after the disconnection of the 'release' current.

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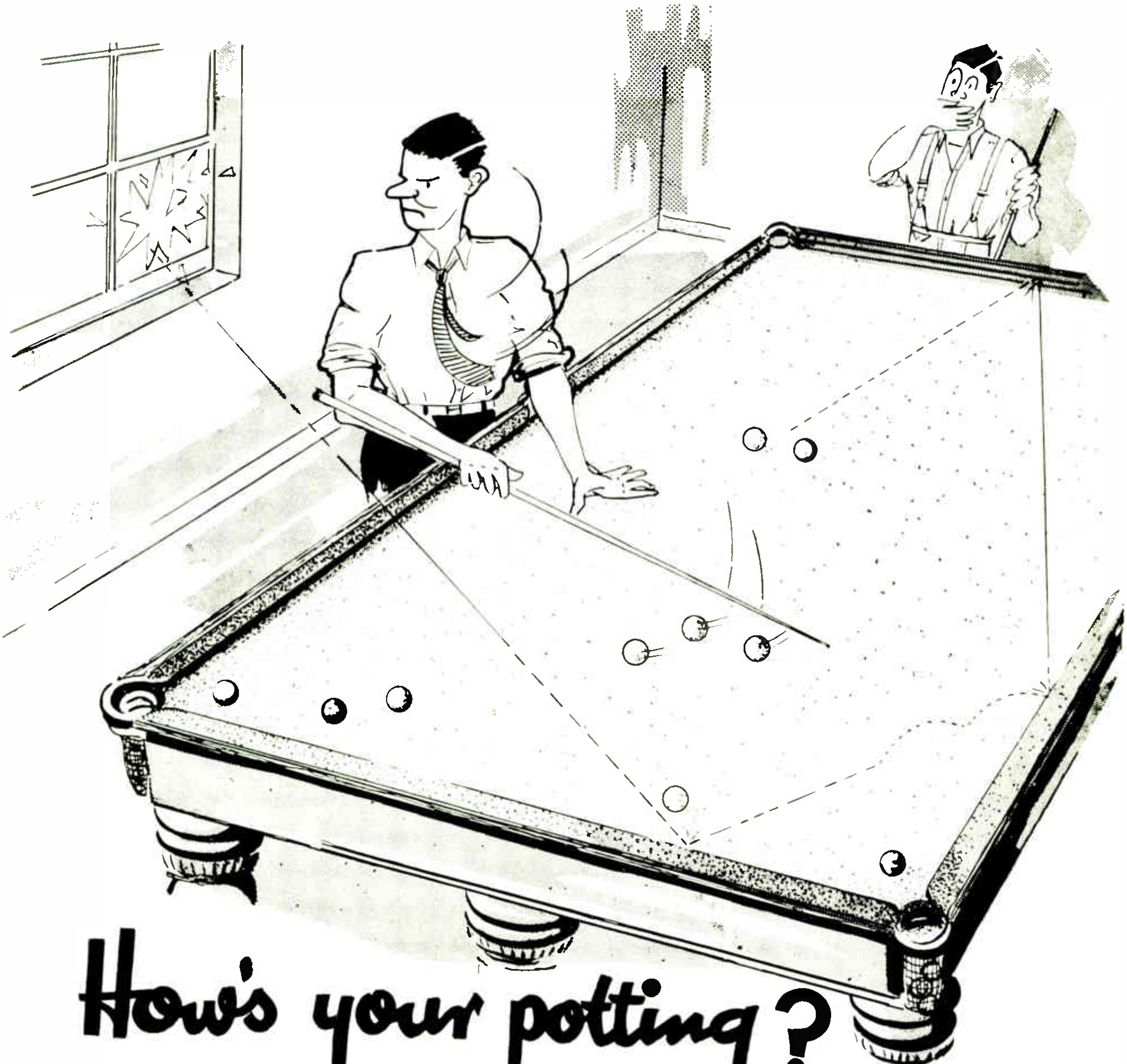

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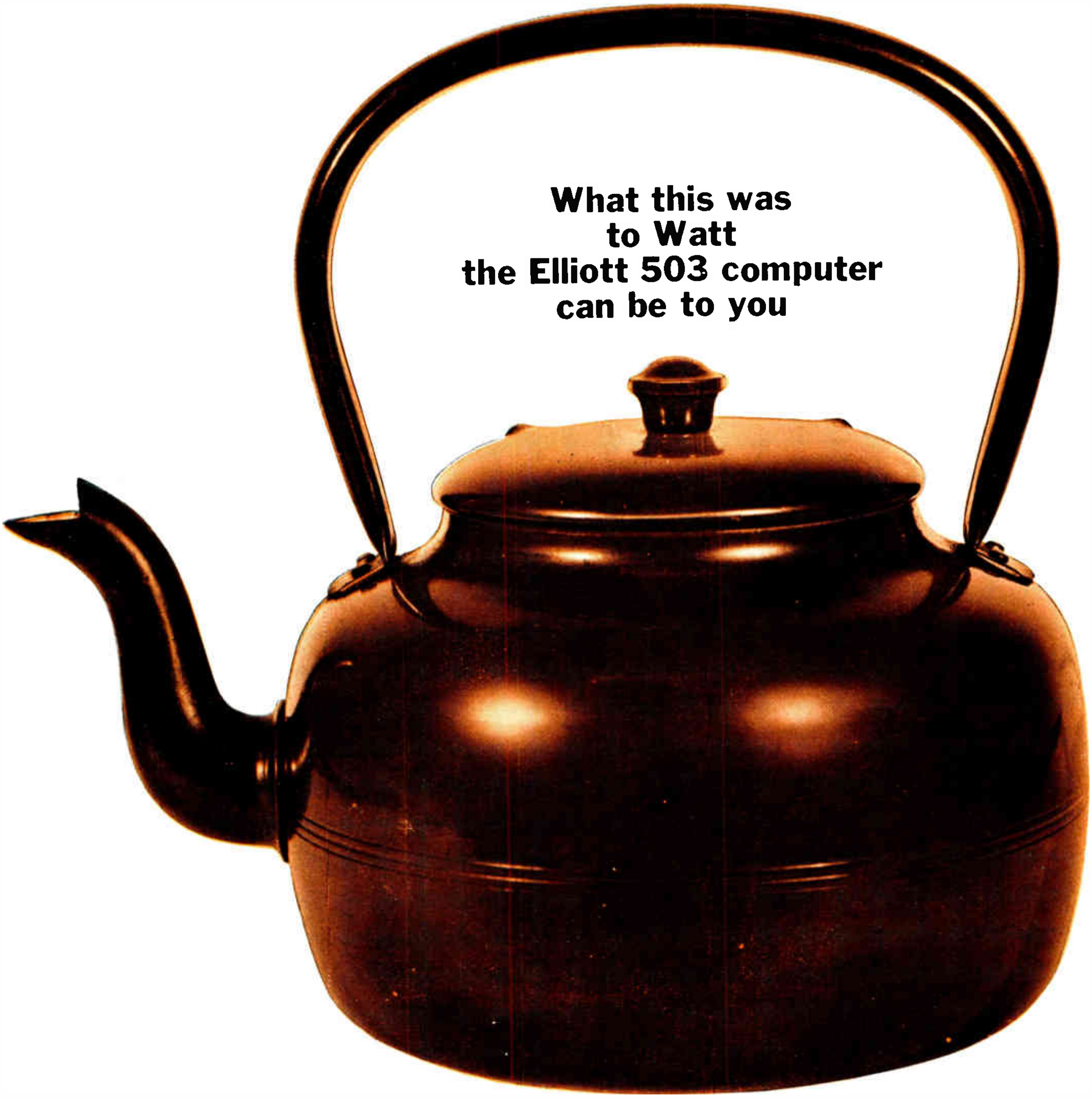

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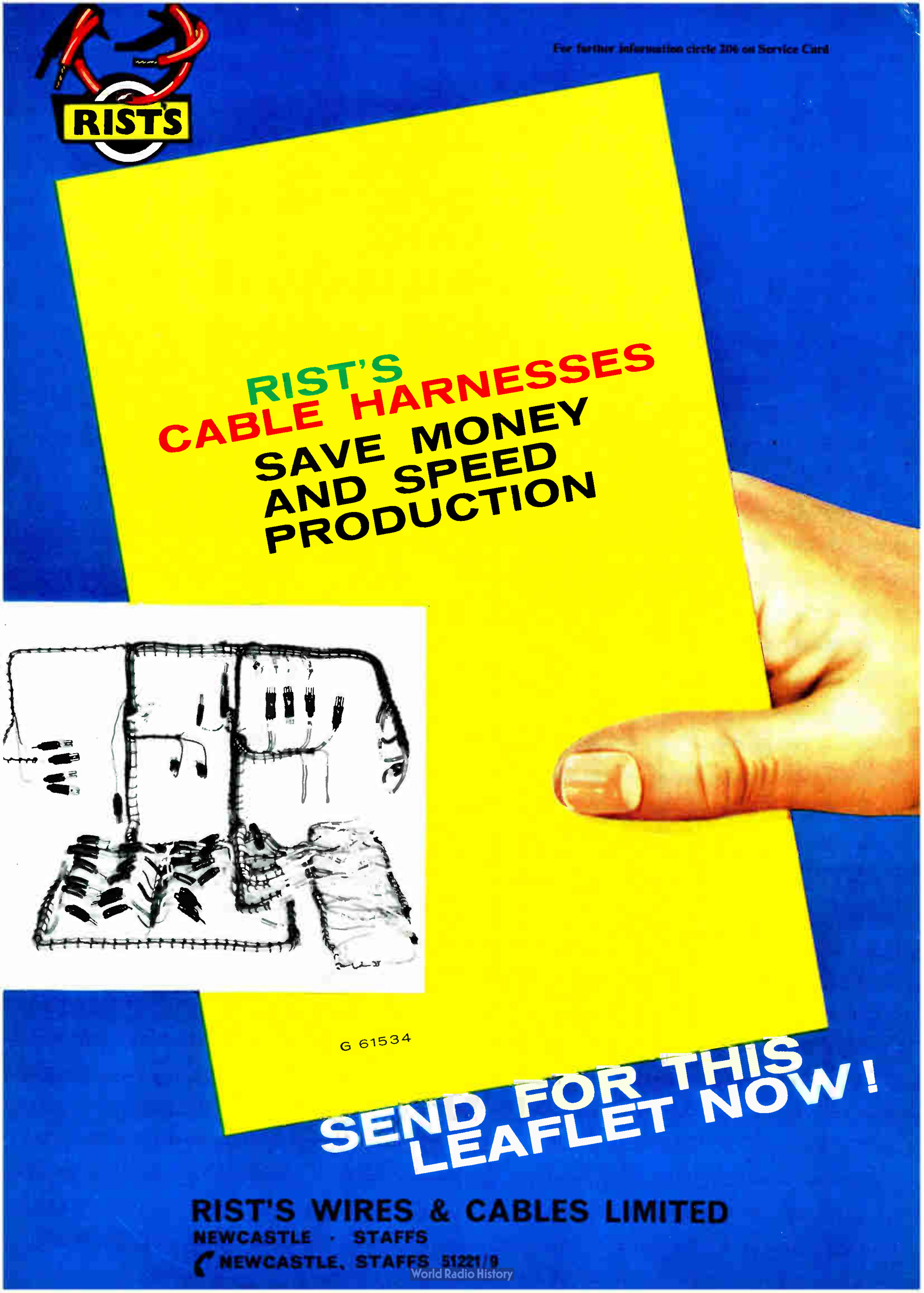

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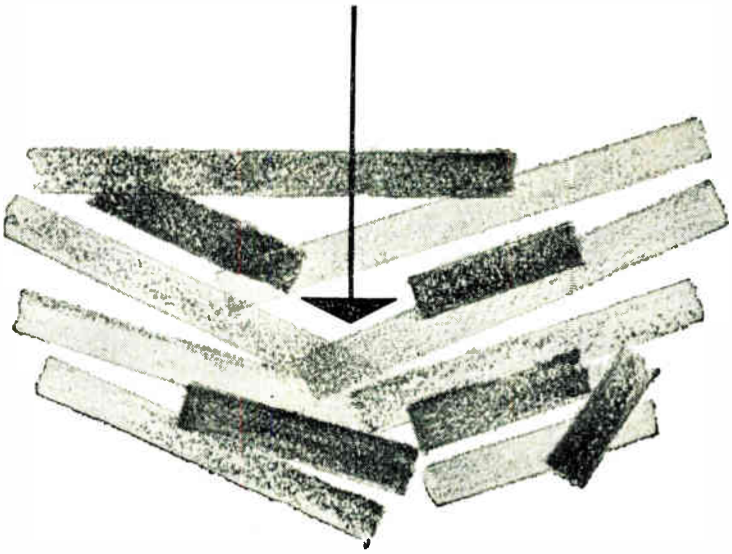

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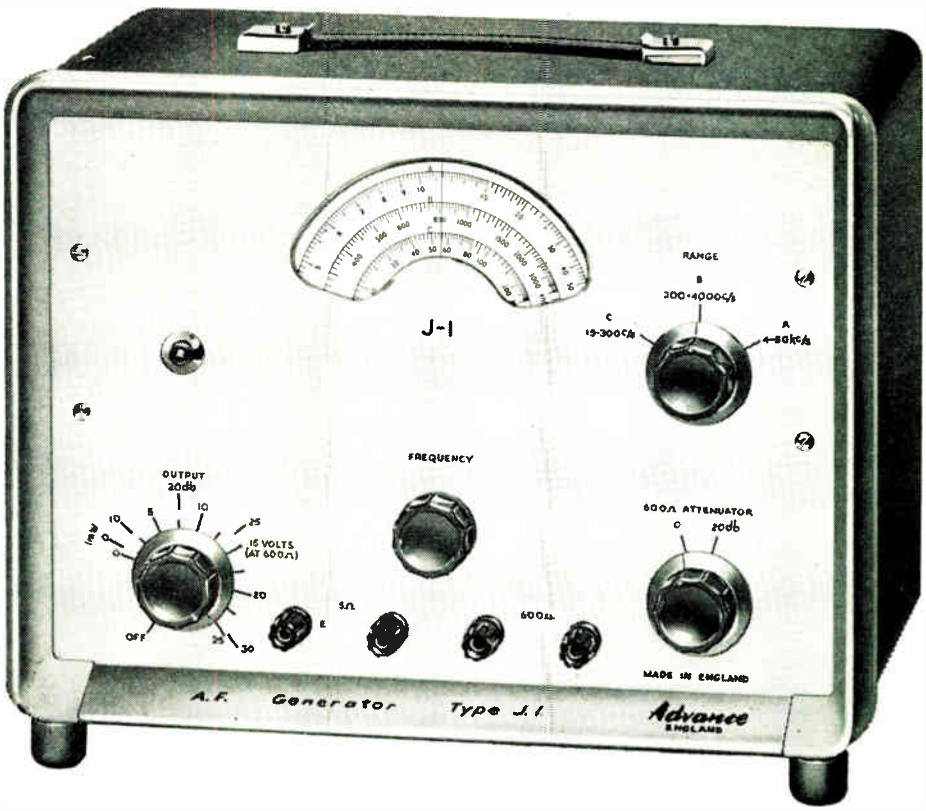

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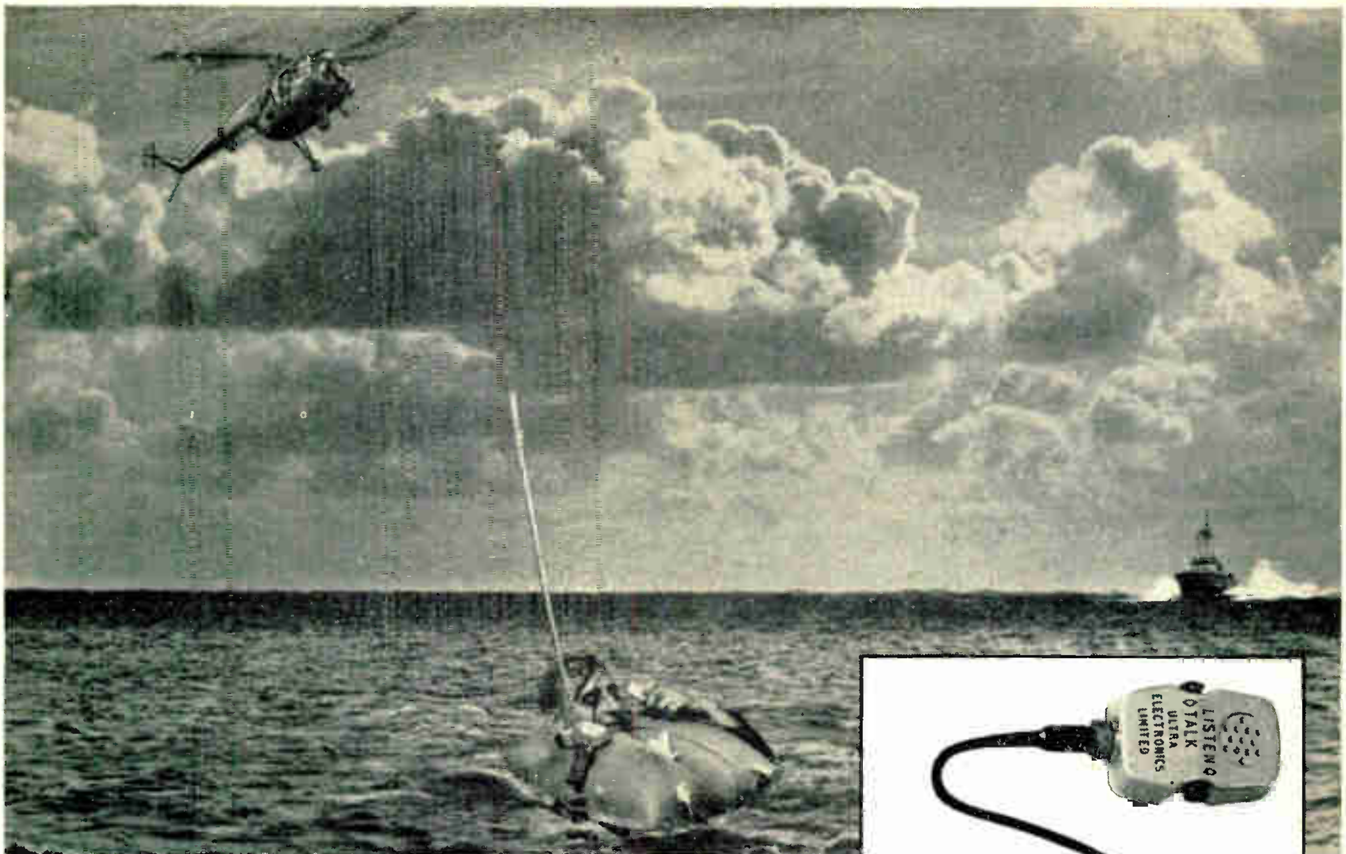

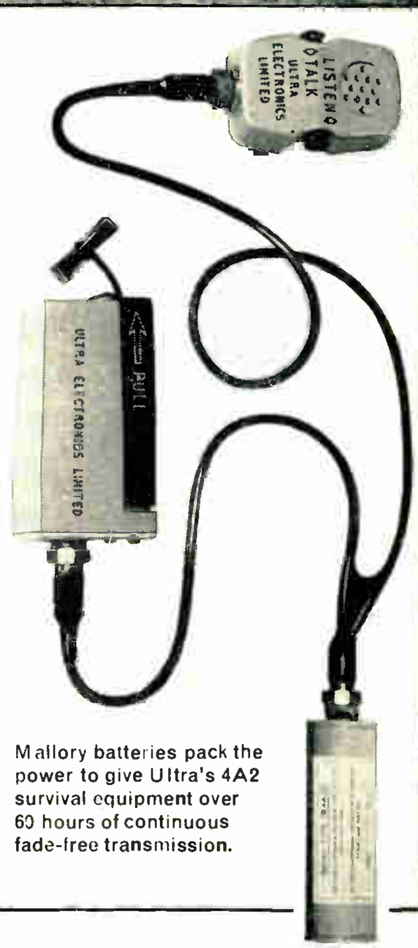

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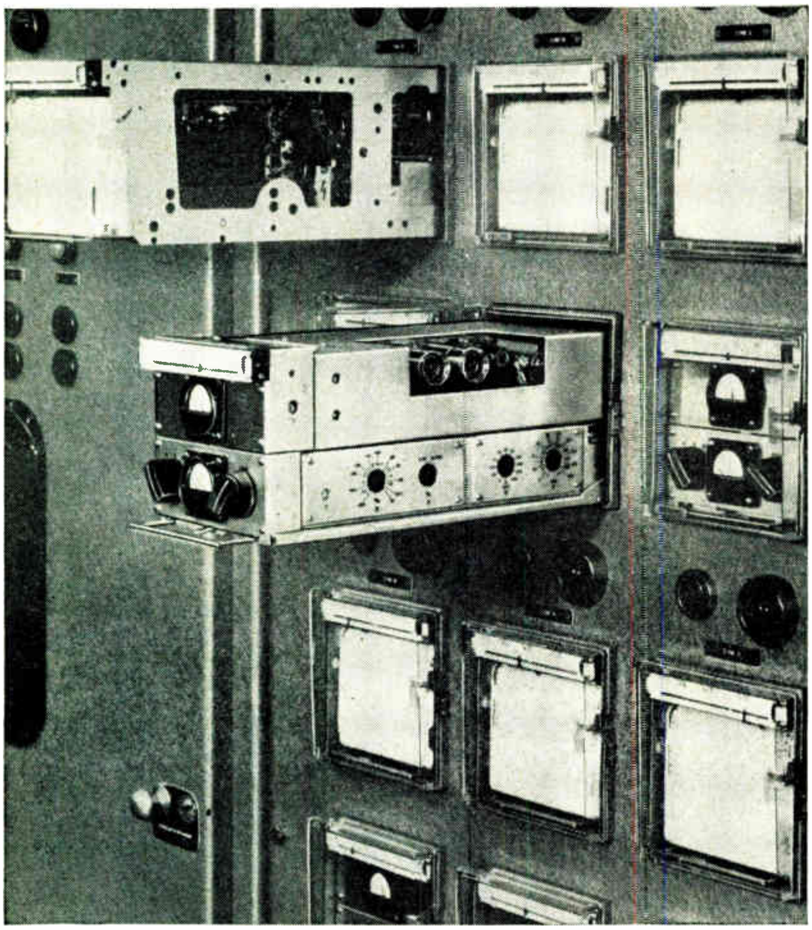

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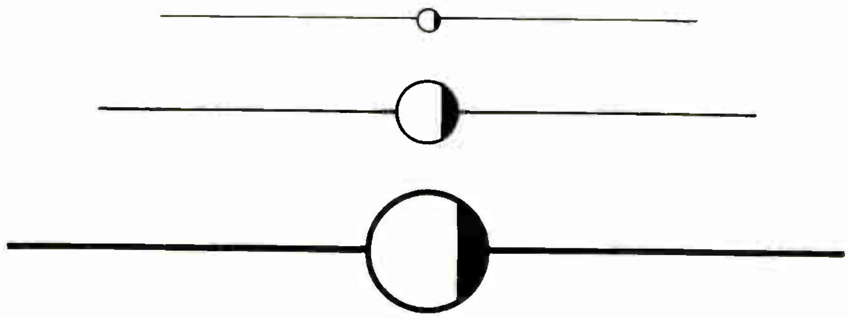

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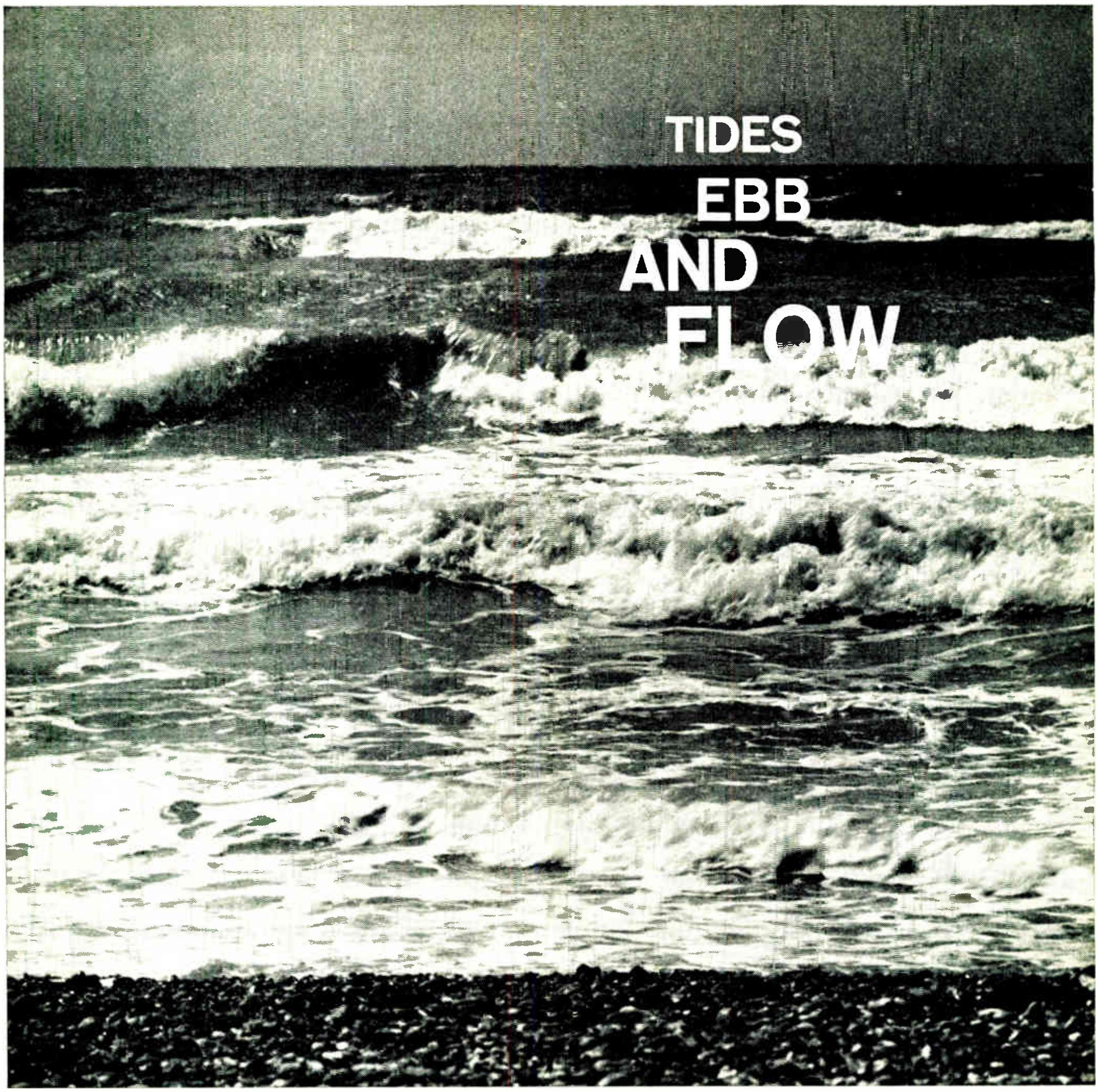

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*HG5004	70	100	0.8	25	-50
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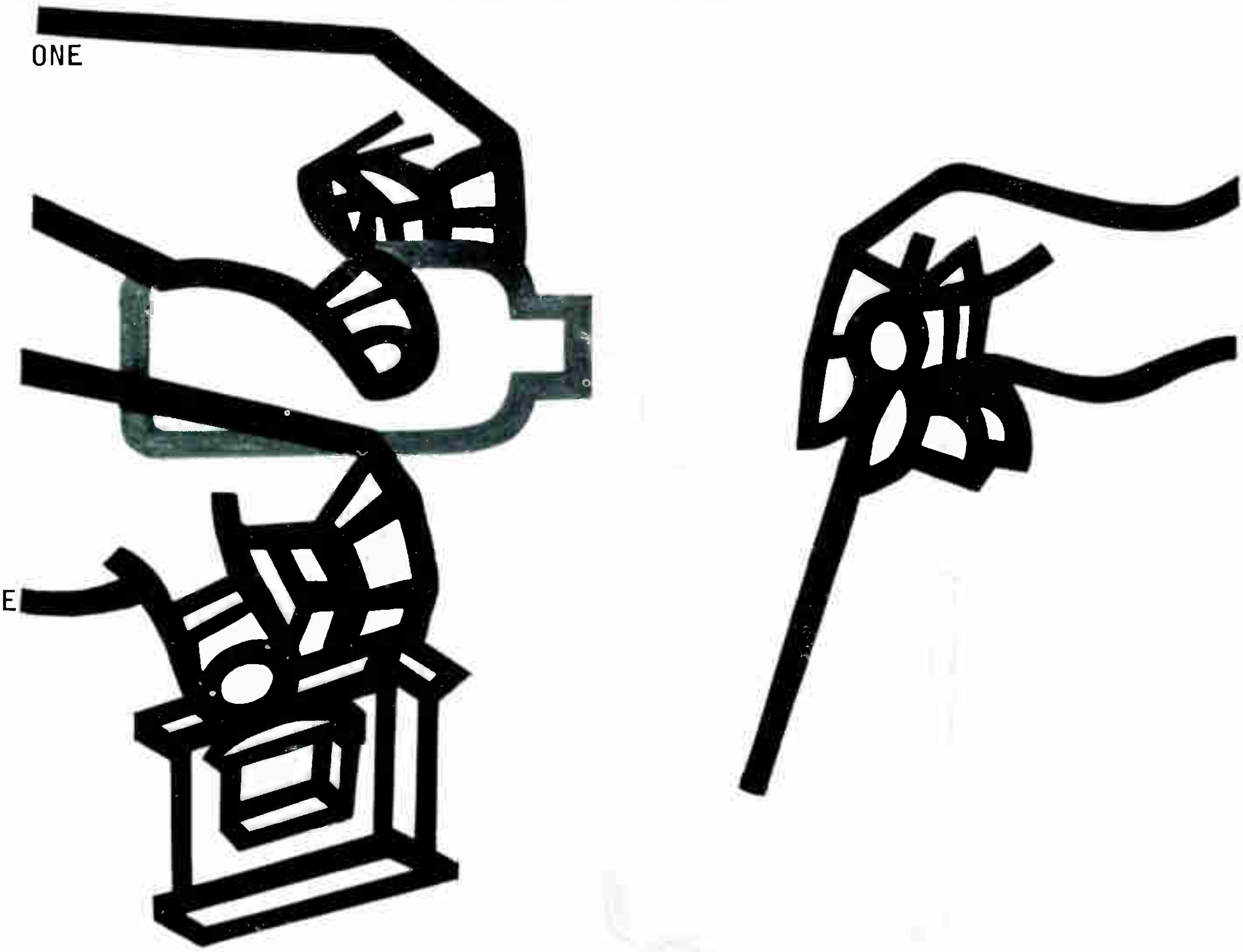

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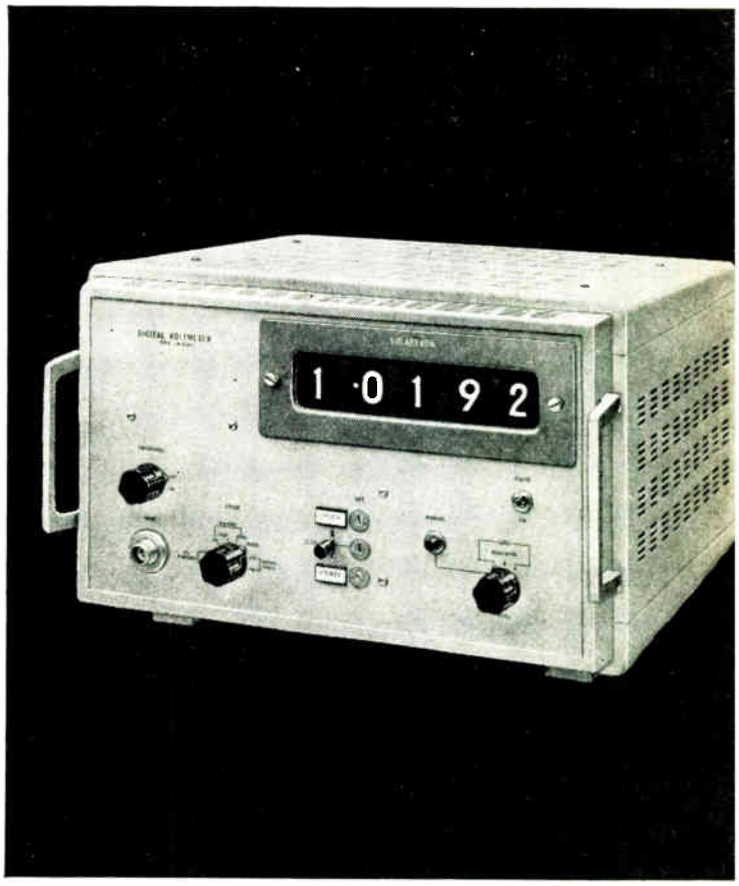

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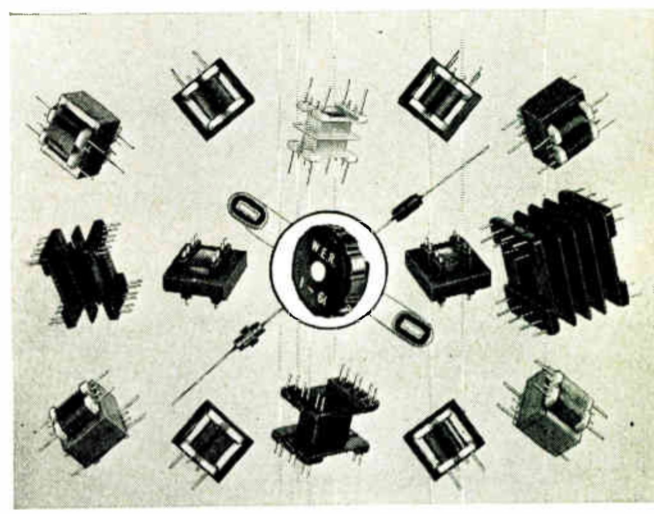

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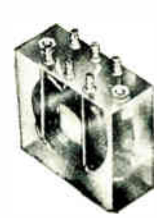

The above illustration shows a range of moulded bobbin assemblies for small transformers and chokes, together with a miniature volume control and switch.

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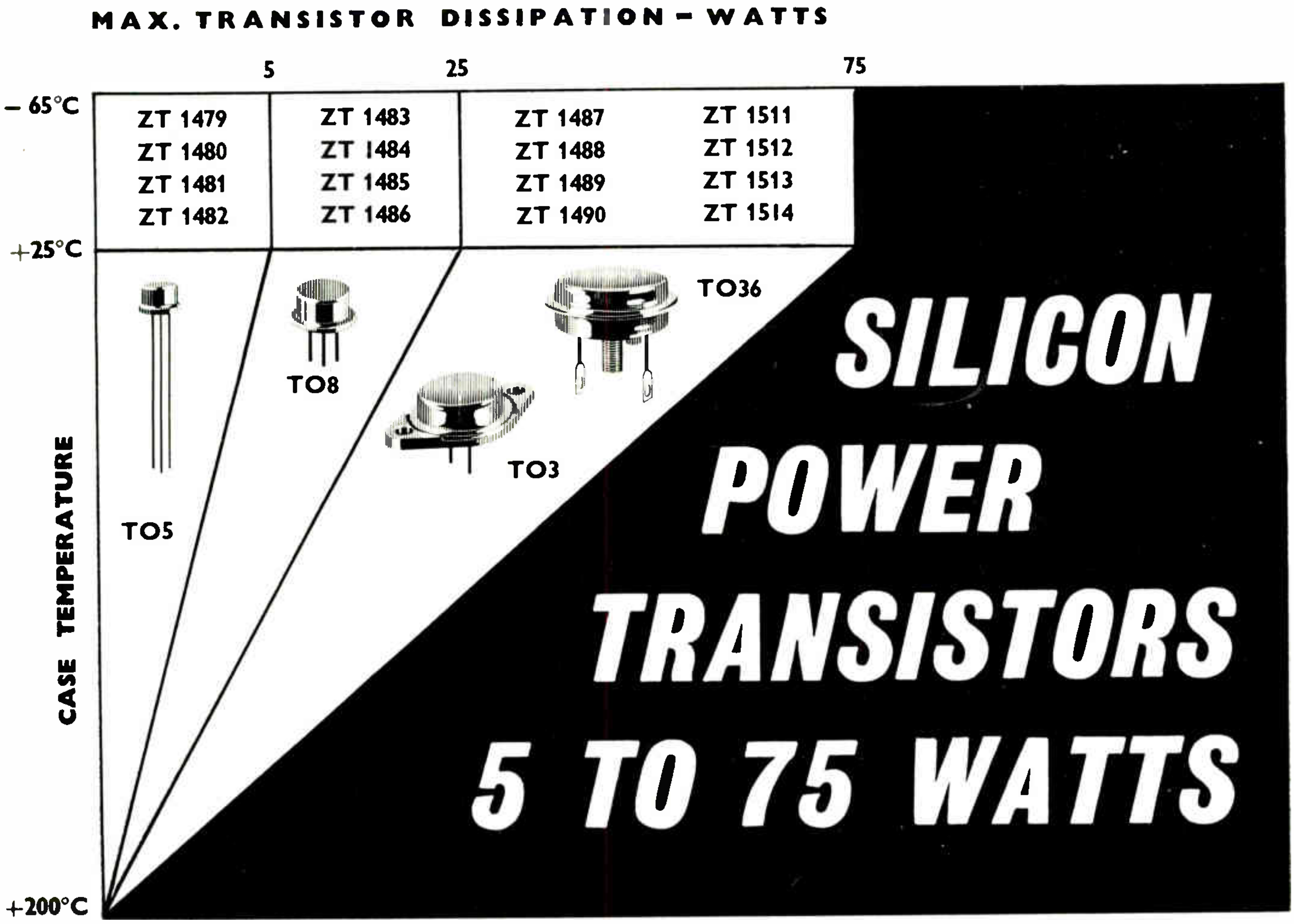

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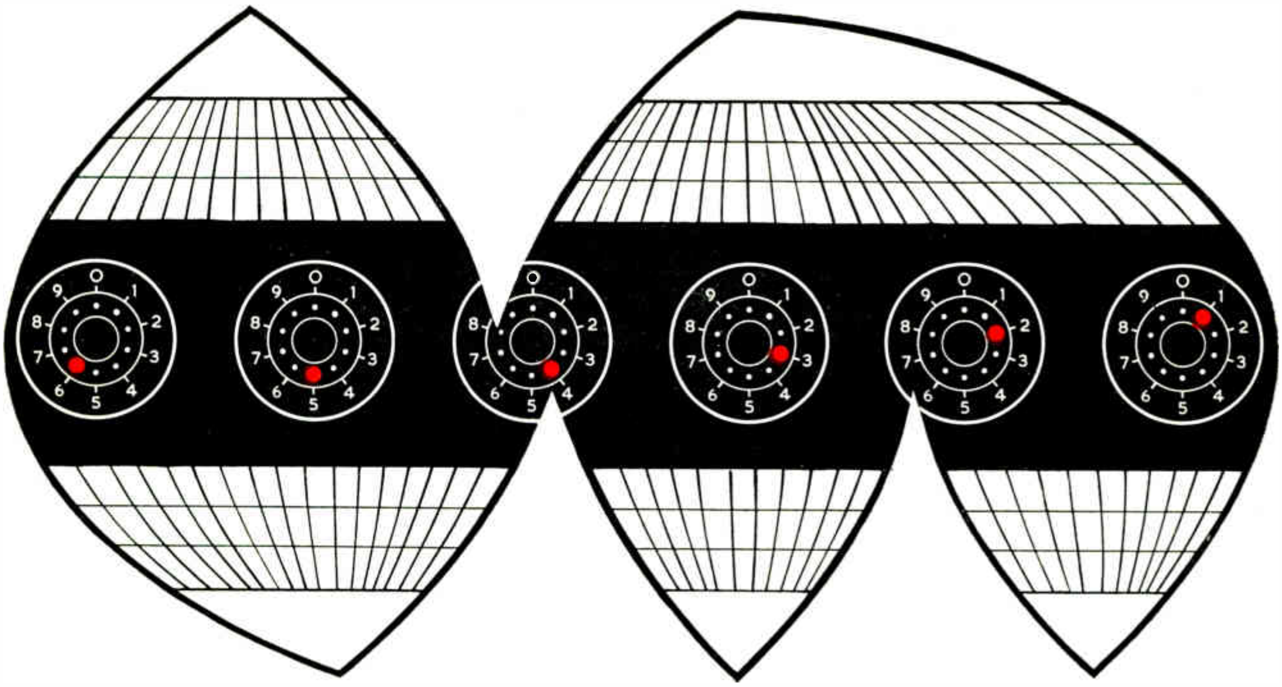

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INDUSTRIAL ELECTRONICS

Comment

We commented last month on 'learning machines'. We now want to say something about 'teaching machines'. To be quite clear about what this means, they are machines which help a person to learn something. They are still rather in the experimental stage, for although quite a number are being used in various places their practical utility is not yet accepted by everyone.

A simple example of which the utility is not in much doubt is an elaborated tape recorder for learning a language. It can clearly help enormously in learning correct pronunciation, for after hearing a recorded phrase the student himself records it and can then compare his own version with the original.

More elaborate machines present the student with information and ask him questions about it. He responds by pressing a button indicative of his answer. If he is right the machine proceeds with the next lesson, but as soon as he is wrong it tells him so and presents the information again, but in a different way, before repeating the question. An essential feature is that he is not allowed to proceed until he answers the question correctly. Here it is obviously important to arrange for there to be enough possible answers which the student can give, otherwise he will soon press the right button because he knows all the others are the wrong ones!

Much greater elaboration than this is found in some apparatus. A kind of feedback mechanism is included so that the machine assesses the student's progress from his answers and modifies its own teaching action appropriately.

There is undoubtedly a future for teaching machines and probably a big one. We think, however, that the designers have still quite a long way to go. This is by no means abnormal in the early days of any new development. In this case it would seem that close collaboration between electronic engineers and the teaching profession is called for.

Milestones in Development

Every now and then there occurs a development which has a major effect upon an industry, or which results in the creation of a new one. Looking back over the years Marconi's work on aerials first made wireless telegraphy a commercial proposition and was the beginning of the radio industry. Next came the thermionic valve which transformed radio communications and laid the foundations for the use of electronics in industry. The cathode-ray tube and the iconoscope came and made television a practical possibility.

Over about the first 50 years of this century these were the outstanding inventions which led to easy and rapid world-wide communications, to sound and television broadcasting, to radar and to a whole new industry manufacturing equipment. There were many other things, of course, and very valuable ones, but none which we think quite so important as these we have mentioned.

In 1948 another occurred, the first transistor. This is already at least as important as the earlier ones. It resulted from research into the properties of semiconductors. Some of these materials had long been known and utilized, but without any real understanding of them. The early crystal detector was a semiconductor diode; the copper-oxide and selenium rectifiers of the 30's were also semiconductor diodes. Although they were manufactured and used on a large scale for a long time no one really knew how they worked and development was largely empirical.

Pure research into materials led to understanding and then research and development walked hand in hand. Now semiconductors are almost an industry in their own right. Knowledge has so increased that new devices are pouring out and it is hard to keep track of them.

Transistors have revolutionized electronics partly because of their efficiency, they need no cathode power supply; partly because of their small size; and partly because of their extreme ruggedness. They have made many industrial applications of electronics really practicable. This is not to say that the valve cannot do most things. It can but not so neatly.

Some things, like satellite communications, would be impossible without semiconductors for not only do transistors minimize power supply requirements but solar cells enable the power to be obtained from the sun.

Lasers

Whenever one of these major developments occurs the device is naturally at first very imperfect and few, if any, people recognize its possibilities. We are wondering if perhaps we are not now at this point with the laser. At the moment it is barely beyond the experimental stage; will it in a few years be hailed as a milestone in development and the basis of yet another industry?

It does something which no other device can do. It produces a beam of light which is very nearly parallel and very intense. More important, the light is coherent. All other sources, so far as we know, produce incoherent light. The laser produces electromagnetic waves in the visible region of the spectrum which are coherent in the same sense as radio-frequency waves are and this means that some of the things which can be done with r.f. waves can now be done with light waves.

The production of the laser is certainly an achievement. Whether or not it turns out to be a highly important one seems to us to depend on what applications are found for coherent light. It is much too early to be able to forecast what these may be.

Electrets

The electret is to electrostatics what the permanent magnet is to magnetism. It is a dielectric permanently polarized in manufacture so that it produces a permanent external electrostatic field. Although it has been known for many years, it seems to have found surprisingly little application.

It is now being applied to 'condenser' microphones and headphones, however, to avoid the need for a polarizing voltage and so a power supply. According to a Bell Telephones report the diaphragm is made of Mylar film aluminized on one side. The film is heated to 120 °C for 15 minutes and then cooled. During the process it is within a 3·5-kV field and the resulting polarization is equivalent to 200 V externally-applied bias.

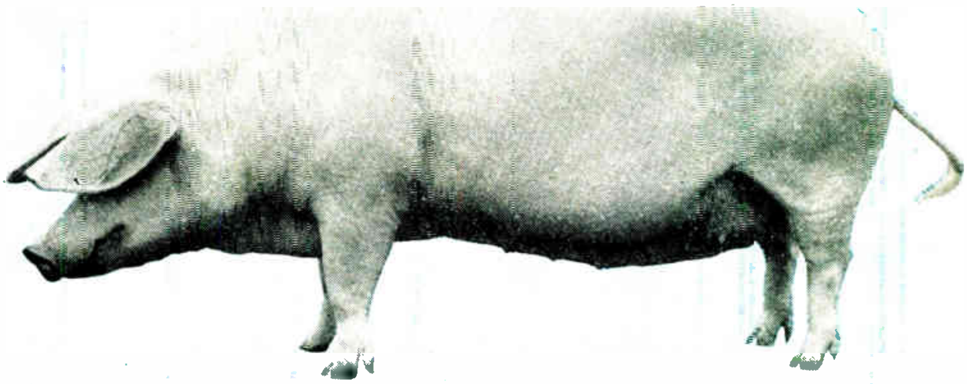
2MT Writtle

The B.B.C. is this year celebrating the 40th anniversary of the start of broadcasting in this country, the official registration of the British Broadcasting Company being 15th November 1922. Prior to that, there were experimental transmissions from that famous station 2MT Writtle which included material most certainly of an entertaining nature.

In our correspondence columns we publish a letter from Mr. B. MacLarty in which he includes the circuit diagram of the transmitter and a photograph of the apparatus. The contrast between this and present-day apparatus well exemplifies the changes which have occurred in 40 years. The circuit is simple in the extreme and yet the size of the transmitter is enormous by today's standards.

We, who well remember listening to 2MT in our early wireless days, have found the details of the transmitter of particular interest. The younger engineers certainly have no personal knowledge of those times but may yet be interested to know what was done then.

ULTRASONIC PIG GRADER



By G. D. CUTLER*
A.M.Brit.I.R.E.

In this article an unusual application of ultrasonics is described—the measurement of fat and lean meat of live and dead pigs. Details of the instrument are given along with results obtained.

THE pig farmer has long wanted a way of finding out the thickness of fat and lean in a live pig in order that he may send it to the right market or choose the right pig for breeding. Even with carcasses, a method of fat measurement which does no damage is very desirable. Conventional cutting methods cause damage which reduces the value of the carcass.

It is now possible to do this by electronic apparatus which functions in a manner analogous to radar or an echo depth sounder. The basic principles are the same, but the system employs ultrasonics. The waves are essentially like those of sound; they are longitudinal waves of compression and rarefaction of the medium. The one difference is that they are of frequencies too high to be detected by the human ear. Waves of this nature of any frequency above about 15 kc/s are ultrasonic.

No special skill is required to grade a pig with the aid of the instrument. All that is necessary is to wet the part of the pig's back where the measurement is to be made—with water or oil—and apply the face of the instrument's probe to the appropriate point. The face of the cathode-ray tube of the instrument will then register spots of light, and these correspond in their positions along a scale to the depths of the various layers of fat and lean. A graticule over the face of the tube is marked directly in millimetres and the reading requires no modifying factor. Detachable graticules with different scales are provided and are used according to whether the measurement is being carried out on a live pig or a carcass, for the wave velocity is slightly different in the two cases. Wetting the skin is necessary to exclude air, which forms a barrier to ultrasonic waves.

* Gauging Systems Ltd.

The instrument is here shown being used on a live pig which is also being weighed

Any air pockets caused by hair or irregular skin formation are filled by the fluid thus forming a continuous path for the waves.

The accuracy of the instrument is better than ± 1% of full scale when measuring accurate test blocks. The Pig Industries Development Association has carried out numerous comparisons using the 'Park Ultrasonic Grader', which is one of the models manufactured by Gauging Systems Ltd. It stated at a recent farmers' conference that the accuracy has been within ± 2% in 70% and within ± 4% in 95% of pigs tested when used to predict the lean and fat content.

The time required for the measurement is insignificantly small which, of course, is one of the attractions of the device. With an operator who is familiar with pig measuring it may be no more than a few seconds. To the farmer who does the measurement himself, probably on live pigs, no difficulty should be encountered in obtaining the appropriate measurements and they should be enough to enable him to decide to which market the pig is best suited. At present, there is no entirely satisfactory way, other than by the use of ultrasonics, of measuring lean and fat layers on a live pig. With carcasses, it is necessary to process to a certain point before measurement is possible by conventional methods. These alternative ways are much slower than the ultrasonic method, or occur at a late stage in the processing, which is a disadvantage to buyers.

The advantages of the instrument are plain. It achieves its results by measuring in radar fashion the thickness of the layers of fat and lean; that is, it measures the time which is taken for an ultrasonic wave to pass through the layer and, reflected at the boundary, to pass back again to the instrument.

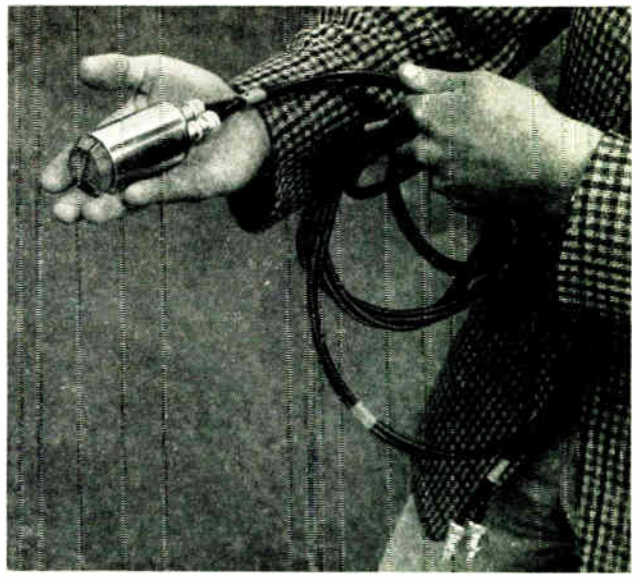
Fig. 1 shows a section through a pig's back at a point where a measurement is to be made. There are layers of fat and lean divided by thin tissue. The change of density at an interface between layers provides an effective reflecting surface for ultrasonic waves. It is, of course, also the distance which it is necessary to know in order to assess the quality of the animal.

A pair of closely adjacent transducers is mounted in a single probe unit and applied to the pig as shown. One transducer is a transmitting element, the other a receiving element. The transmitter produces a divergent beam of ultrasonic waves which travel through the animal and are reflected by the various layers. The receiver is sensitive over a similar beam-like area, and the effective coverage for measurement purposes is thus the cross-hatched area in Fig. 1, where the two beams overlap.

In a given medium ultrasonic waves travel at a constant velocity, which is about $1{\cdot}4 \times 10^5$ cm/sec in animal flesh. If a signal is applied at the transmitter it takes time for it to pass through the flesh, and for the reflection from a layer to pass back again to the receiver. A measurement of this time interval is thus a direct indication of the distance which the wave has travelled in the animal, and this is twice the distance from the skin to the reflecting layer. Actually, the fact that transmitter and receiver are laterally separated introduces a cosine error, but this is kept negligibly small by careful design.

A cathode-ray tube is used as an indicator. The electron beam produces a spot of light on the face of the tube where it strikes it. The beam is made to move across the face of the tube horizontally from left to right at a constant rate, so that it traverses the tube face in about 150 μsec. This corresponds to a wave distance of 20 cm and so to a reflecting layer 10 cm below the skin.

The spot on the tube screen traverses the screen from left to right at a constant rate in 150 μsec; it then rapidly flies back to the left. This whole process of a constant rate scan



This illustrates the probe and shows the ends of the transmitting and receiving elements. They are separated by an ultrasonic damping medium to reduce direct pick-up by the receiving element from the transmitter

and rapid flyback is regularly repeated, and if the spot excited the screen continuously it would draw out a visible horizontal line of light.

The spot is normally blacked out, however. The voltages which cause the spot to move and which are generated in the equipment, also control the transmitter. The flyback energizes the transmitter and causes it to produce a short pulse. After travelling through the animal any reflected pulses energize the receiver and, after amplification and

The simple arrangement of controls is clearly shown in this close-up view. The model illustrated has a circular measuring scale instead of the horizontal one described in the text

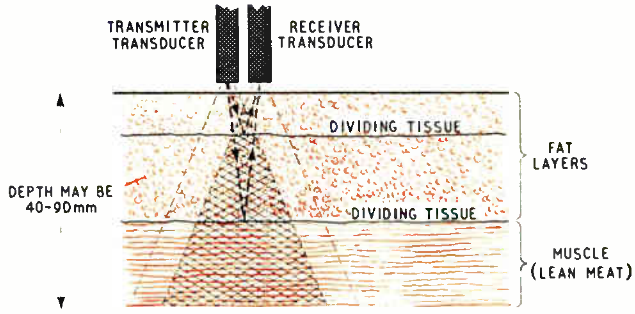


Fig. 1—A typical section through a pig's back

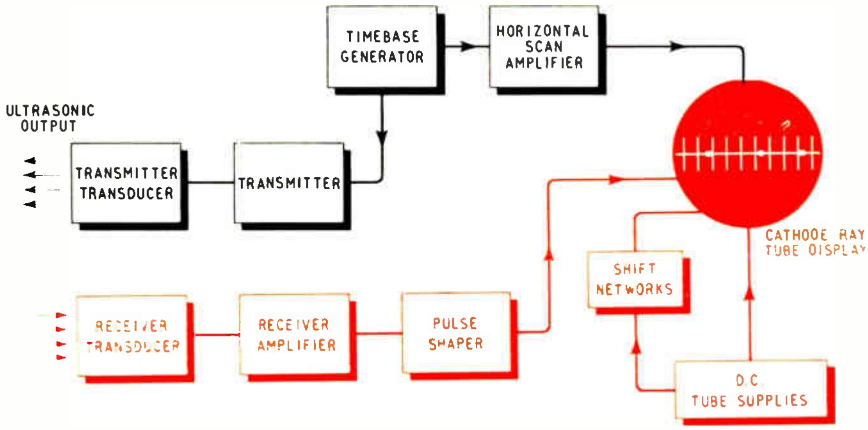


Fig. 2—The block diagram of the measuring instrument

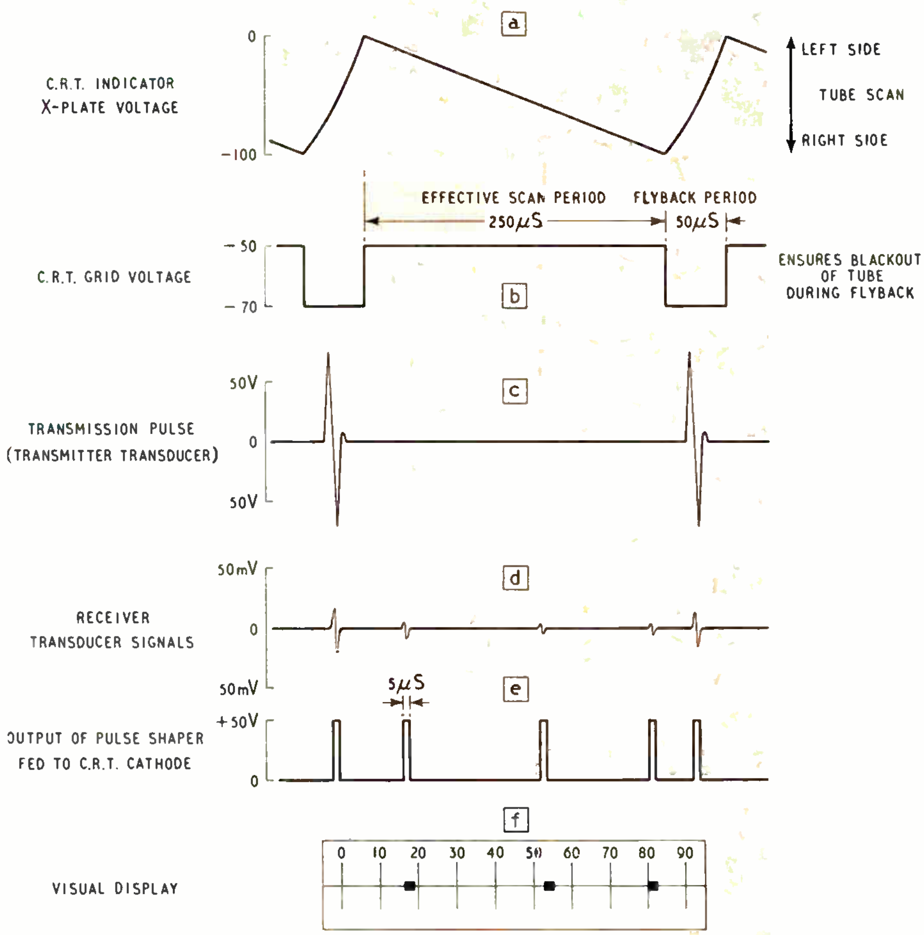


Fig. 3—The waveforms in the system and the c.r.t. display pattern

other suitable treatment, produce a pulse which turns on the electron beam in the cathode-ray tube. Thus a bright spot appears on the tube face and its position against a scale indicates directly the depth of the reflecting layer.

A block diagram of the apparatus is shown in Fig. 2. A Puckle timebase generator and amplifier produces a push-pull saw-tooth waveform which is applied to the X-plates of the c.r. tube. This is shown in Fig. 3(a). A pulse is developed on flyback (b) which is applied to the c.r. tube modulator to black-out the spot during flyback. It also turns on the transmitter, and a pulse (c) is produced by the transmitting transducer.

The received signal is of the form (d). After amplification it is used to trigger a pulse generator which supplies a brightening pulse to the modulator of the c.r. tube. It is arranged so that only signals above a certain level will trigger the pulse generator. The result is that only the main strong reflections produce spots on the tube and a confusing clutter of weak reflections is avoided. The triggering level can be adjusted by an amplifier gain control.

The probe containing the two transducers is connected to the instrument by a cable. The electronic apparatus is contained in a heavy-gauge steel case which, of course, for farm use has to be water-tight. Power is drawn from the a.c. mains for these are now normally available on farms. In cases where they are not, the instrument can be operated from batteries with the aid of a d.c.-a.c. convertor.

The instrument shown in the photographs is slightly different to the one described here in that it has a circular 'clock-face' presentation of the measurement instead of a horizontal scale. This is the one referred to earlier as the 'Park Ultrasonic Grader' and it is in use in many leading bacon factories. Development is still continuing and it is expected eventually to produce one using only transistors. The device naturally has applications beyond pig grading, and one model is being developed for medical purposes.

'Gauging Systems Ltd.' are a design and development organization in this context and the 'Park Ultrasonic Grader', marketed by 'Park Ultrasonics Ltd.', is the currently marketed version of the pig grader.

TOOTHPASTE AND ELECTRONICS

The recent introduction of a toothpaste containing fluoride by Unilever Ltd. created an interesting problem for W. G. Pye—that of producing a complete pH detection system small enough to be accommodated on the surface of a human tooth.

As a result a new microelectrode has been evolved which has a 2-mm diameter spherical membrane as shown in Fig. 1. The technique used for measuring the pH of a fluid on the surface of a tooth is illustrated in Fig. 2. A wax ring is firmly attached to the tooth and filled with a suitable liquid. The pH can then be measured directly by inserting the tips of the glass microelectrode and a conventional wickbleed reference electrode.

This technique has been applied in the laboratories of Unilever Ltd. A small amount of lactic acid, of pH 4·4, was arranged to contact a small area of the tooth enamel of a number of children who had not used the fluoride-containing product. After 3 min the pH of the acid was again measured and showed an average increase of 0·51 to pH 4·91, indicating some reaction with the enamel.

The same test procedure was then repeated with children who had used the fluoride-containing toothpaste for three weeks. In these cases the change in pH of the acid after 3 min contact averaged 0·41 to pH 4·81, indicating a reduced acid-enamel reaction.

Although the application described is of a special nature, this new electrode should find many uses in other applications. The small size of its membrane makes it particularly useful for micro-analytical work in the industrial laboratory where the size of the sample can be extremely small and simple measuring apparatus is an advantage.

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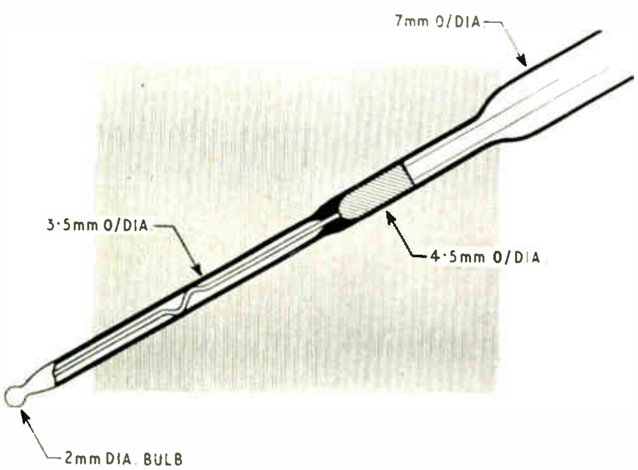


Fig. 1. This drawing clearly illustrates the small dimensions of the microelectrode

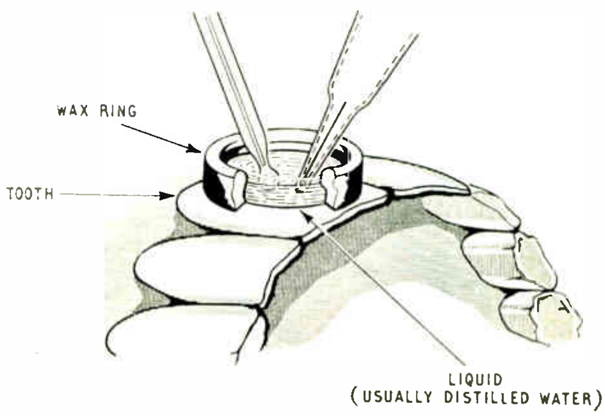


Fig. 2. Here a solution of the problem of measuring the pH of a fluid on the surface of a tooth is shown

Developments in semiconducting materials have led to the production of a whole group of photocells embodying them. These have different characteristics from the better known vacuum and glass types and so find different applications. In this article the photovoltaic and photoconductive types are described.

SEMICONDUCTOR PHOTOCELLS

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

IN a previous article the characteristics of vacuum, gas and photomultiplier cells were described. For some applications these photocells have no rival, but for others the semiconductor types are more suitable, and have characteristics which are quite different from the vacuum and gas types. They fall into two main groups, the photovoltaic cells and the photoconductive, and some are noteworthy for high sensitivity in the infra-red region of the spectrum.

Photovoltaic Cells

These solid-state cells depend for their action on the existence of a rectifying junction at an interface between a transparent metal film and a semiconductor such as selenium, or between p and n type semiconductors, such as silicon. A 'built-in' voltage V_0 (typically about 0·5 V), exists across this barrier, and sweeps apart electrons and holes formed by the ionizing action of radiation. The space charge produced by the accumulation of electrons on the positive side of the junction, and positive holes on the negative side, causes a current flow in an external circuit, and under short-circuit conditions this is proportional to the light intensity, until saturation sets in at high light levels. With a resistive load, the photovoltaic p.d. biases the rectifying junction in the forward, conducting, direction, and the photocurrent is divided between the load and the diode conductance. The open-circuit voltage, V_e, tends to V_0 as a maximum, and is proportional to the logarithm of illumination, as shown in Fig. 1.

Selenium cells, having a peak response in the blue-green, are readily corrected by a suitable filter, losing only 50% of the light, to give a curve approximating standard eye response, as shown in Fig. 2. Characteristics of this type of cell are summarized in Table 1, and the photograph illustrates a typical range, the areas obtainable being from ¼ to 30 cm². Selenium cells are operated into low-resistance meters to give a linear light–current relationship, and used in this mode they have a good temperature coefficient. With a high impedance meter, giving a logarithmic response, the temperature coefficient is worse. The poor frequency response of 3,000 c/s is caused by the high capacitance of the barrier, coupled with the internal impedance of the cell, but this is of no consequence in their widest application, namely photographic exposure meters.

Silicon p-n cells are formed by diffusing an impurity into the surface of a slice of p-type Si, to convert the surface layer into n-type (n-p cells are also made). The junction is formed at the n-p interface, and the surface layer is effectively transparent to radiation so that the useful light can reach the sensitive volume. These cells are sensitive out to 1·1 μ, and have characteristics as shown in

Typical selenium photocells made by Evans Electroselenium Ltd

* E.M.I. Electronics Ltd.

Table 1. They are made in areas from 2 mm^2 to 4 cm^2, and have a faster response than selenium, so that they are much used in punched-card and tape readers.

Operated into an optimum load, silicon cells can give good power conversion, and solar cells are made with a heavily doped surface layer which gives efficiencies of 10–15% for sunlight.

Thallium sulphide photovoltaic cells were made in 1939, but do not seem to be commercially available. They have a better infra-red response than silicon, as shown in Fig. 2.

Photoconductive Cells

A junction cell operated with reverse bias, acts as a photoconductive device, as will be seen from Fig. 1, but the reverse leakage current should be small. Most silicon p-n cells will not accept a reverse bias of more than 1 V, but germanium p-n cells are available giving a dark current at 20 °C of 25 μA, with 25-V bias, for a sensitive area of 2 mm^2 and a sensitivity of around 10 mA/lumen. The dark current is 250 μA at 50 °C, however.

Germanium p-n-p transistors are also made, with a similar spectral response (up to 2 μ) and sensitivity, but with an internal amplification of 50, and a response time increased from the 2-μsec of the junction to about 100 μsec. The small sensitive area and high-sensitivity recommend these devices for optical positioning controls.

A range of semi-insulators exists in which internal amplification is provided by the trapping of light-produced charge carriers at impurity centres and crystal boundaries, for a time long compared with the transit time of electrons between electrodes applied to the surface of the material. In these cells the effect of light is to vary the resistivity of the unit, as shown in Fig. 3, which gives data on CdS and CdSe cells. These have photoconductivity in the visible region (Fig. 4), but it should be pointed out that the spectral response depends very much on the method of preparation, and some CdS cells have more red response than the curve of Fig. 4.

These cells are available with sensitive areas ranging from less than 1 mm^2 to 5 cm^2, with dark resistivity at 20 °C of between 0·1 and 100 MΩ, depending on the type, and sensitivity at the recommended working voltage of between 1 and 20 amps per lumen of 2,870 °K tungsten light, for low-light levels. The response time of the cells and their temperature coefficient depend very much on the light level, being much worse at low level with values of 1 sec and −1% per °C. (CdSe is faster but worse for temperature than CdS.) An effective upper limit for use is 50–60 °C. Their current capacity of tens of milliamperes makes them widely used in on-off light relay circuits, such as street-lighting control and flame-failure detection in furnaces. All of these solid-state photocells are inherently rugged.

The other cells with infra-red response in Fig. 4 are normally required to detect small incident power so the change of cell resistance under irradiation is also very

TABLE 1
CHARACTERISTICS OF PHOTOVOLTAIC CELLS

Type	Short-circuit current (2,870 °K tungsten light) (mA/lumen)	Saturated output (mA/cm²)	Open-circuit voltage, saturated output	Time Response (μsec)
Selenium	0·3–0·5	1	0·3–0·5	100
Silicon p–n	3–10	>50	0·5–0·55	0·1–20
Thallium sulphide	0·5–5	—	—	—

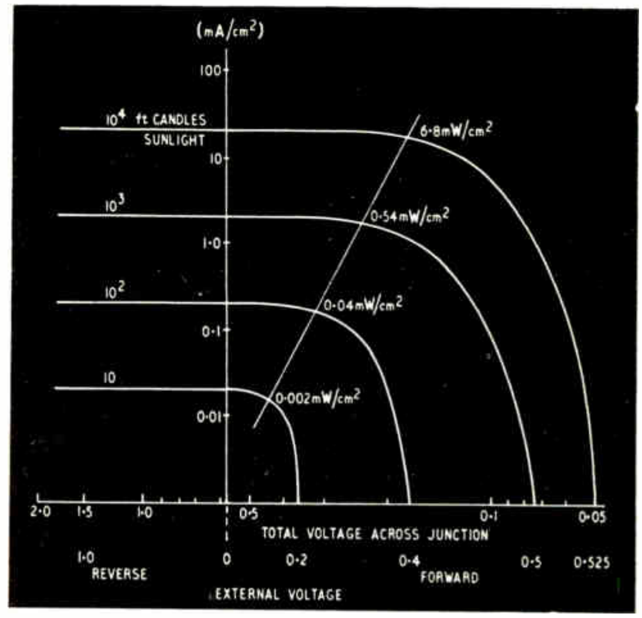


Fig. 1.—Characteristics of typical silicon p-n solar cell

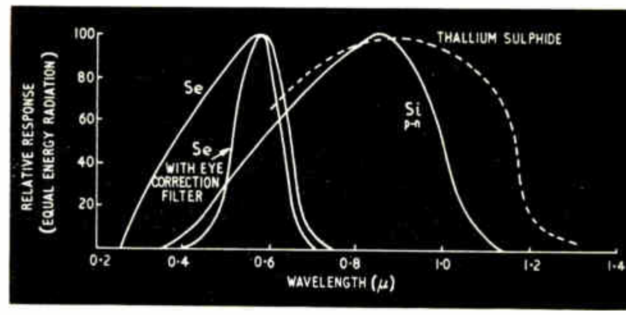


Fig. 2.—Spectral response of photoconductive cells

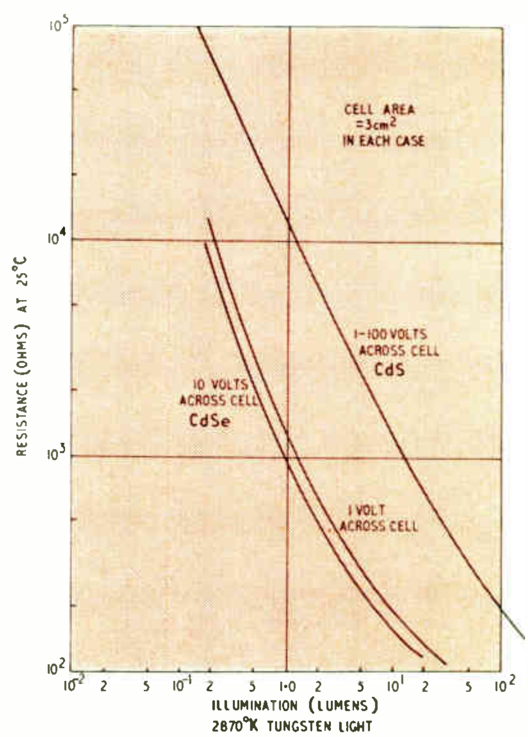


Fig. 3.—Variation of resistance with illumination of E.M.I. CdS and CdSe photocells

small. The signal voltage across the load resistance, which comes in series with the cell and supply voltage, is very small indeed compared with the standing voltage across it. The normal method of operation, therefore, is to modulate the light source at a frequency small compared with the reciprocal of the cell time constant, so that the resulting a.c. signal can be amplified by a low-noise amplifier.

The main sources of noise are then the current noise (usually large compared with the Johnson noise in the load), and shot-noise due to fluctuations in the number of quanta absorbed. At the peak of the response curve the quantum efficiency is almost unity, so measurements of cell sensitivity may be related to the input radiant power at peak response required to give a signal equal to the noise developed across the load resistor.

The current noise and the signal output per watt of incident radiation are both proportional to the cell current over an appreciable range, so that the signal-noise ratio is independent of the current provided that it is low enough for joule heating of the cell to be negligible. The noise equivalent power, n.e.p., for monochromatic radiation of wavelength λ, near the peak response, is proportional to $\lambda\sqrt{A}$ where A is the cell area, and it is often useful to compare cells by the normalized detectivity $D^* = A^{\frac{1}{2}}$/n.e.p. cm/watt, n.e.p. being specified for an amplifier bandwidth of 1 c/s.

Table 2 summarizes the characteristics of some infra-red photo-conductive materials and includes this 'detectivity'. The improvement obtained by cooling to liquid air temperature, 77 °K, should be noted.

The sensitivities of cells using the above materials, when operated with a load resistor of 1 MΩ (except InSb which is normally transformer coupled), varies from tens to hundreds of microvolts per microwatt of radiation from a black body at 500 °K, with a supply of 200 V (again excepting InSb). PbS, with good extension into the visible, gives about 3 mA/lumen to 2,870 °K tungsten light. This has given an interesting use in stereophonic film sound heads, where one channel is carried by magnetic oxide coated over the normal sound track which is read by a PbS cell through the oxide film by transmitted infra-red. The more normal applications of infra-red sensitive photo-

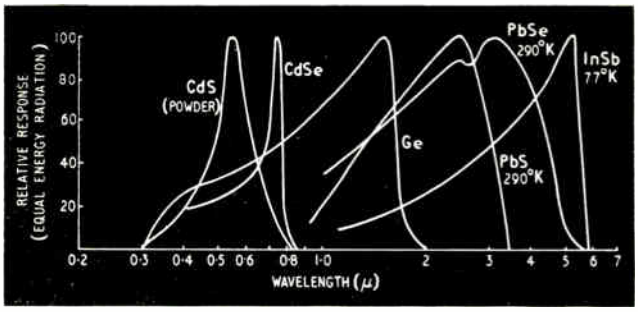


Fig. 4.—Spectral response of photo-voltaic cells

TABLE 2
CHARACTERISTICS OF INFRA-RED PHOTOCONDUCTIVE MATERIALS

Material	Temperature (°K)	Spectral Range (μ)	Peak Response (μ)	D^* (cm/watt) × 10^9	Time Constant (μsec)
PbS	290	0·3–3·5	2·5	1	75
	77	0·3–4·5	4	3 to 6	500
PbSe	290	1–5	3·3	0·2	1
	77	1–8	6	1	10
PbTe	77	0·6–6	4·2	1·5	10–1,000
InSb	290	0·4–8	6	0·2	1
	77	0·4–5·4	5	20	—

conductive cells, however, lie in spectroscopy and in military equipment.

In this article and the previous one (*Industrial Electronics*, November 1962) the characteristics of currently available photocells have been summarized and an indication has been given of their main fields of application. A future article will deal specifically with industrial applications.

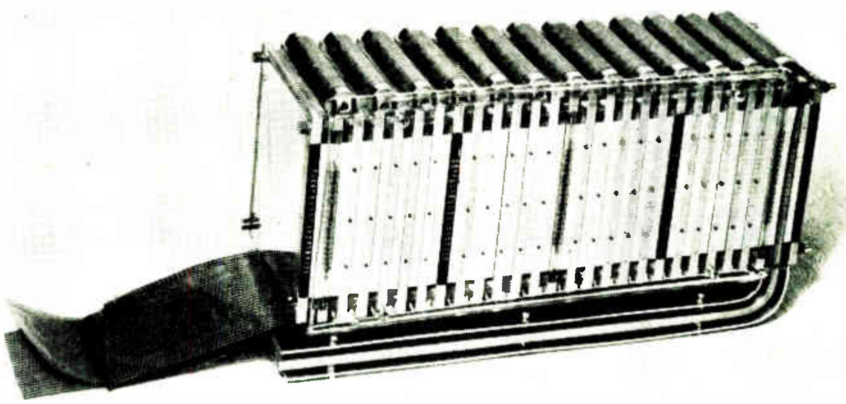
Acknowledgments

Material provided by Evans Electroselenium Ltd.; Ferranti Ltd.; Hilger and Watts Ltd.; and Mullard Ltd. has been consulted in the preparation of this article.

High-Speed Computer Store

The Hirst Research Centre of the G.E.C. is developing in conjunction with the I.C.T. Laboratories a fast magnetic-film store; it is now nearly through the pre-production stage. Reading times of 2 nsec have been achieved.

The photograph shows one unit of a large store: it has 50 plates each with 520 storage elements. Production units will probably have 832 elements. A store incorporating three units would be inexpensive and have a capacity of some 4,000 words (200,000 elements) with a read-write cycle of 1 μsec.



Applications of THERMOELECTRIC COOLING

By *J. E. BEAN**

An earlier article described how thermoelectric cooling devices work. Here some typical applications are discussed.

CONSEQUENT upon the great development in semi-conductors during recent years, the Peltier effect has ceased to be a laboratory curiosity and become a very practical method of obtaining cooling, especially for heat transference of a few calories per second. A recent article (*Industrial Electronics*, November 1962) described the effect in detail and explained the conditions needed for successful operation. In this further article, the advantages and applications are discussed.

The main advantages of thermoelectric cooling devices over more conventional forms of cooling equipment may be listed as follows:

(a) The cooling power is continuously variable, making this type of device ideal for use in automatic control systems.
(b) The function of these devices may be switched from cooling to heating simply by reversing the direction of the applied current, thus permitting the control of temperatures at levels above or below ambient.
(c) Since thermoelectric devices have no moving parts they are silent in operation, and have a long and reliable life.
(d) They are not affected by attitude.
(e) They are compact, and therefore ideal for use in small instruments.

Applications to which thermoelectric cooling devices are particularly suited include the cooling of transistors; temperature stabilization of frequency-controlling crystals; cooling of parametric amplifiers; distillation plant; temperature stabilization of gyroscopes; cooling of microscope and microtome stages, and many others too numerous to mention. Salford Electrical Instruments Ltd. have developed

* Salford Electrical Instruments Ltd.

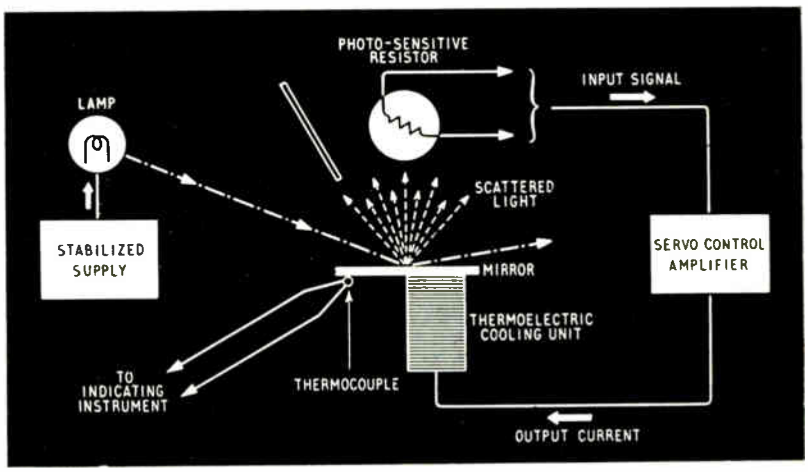
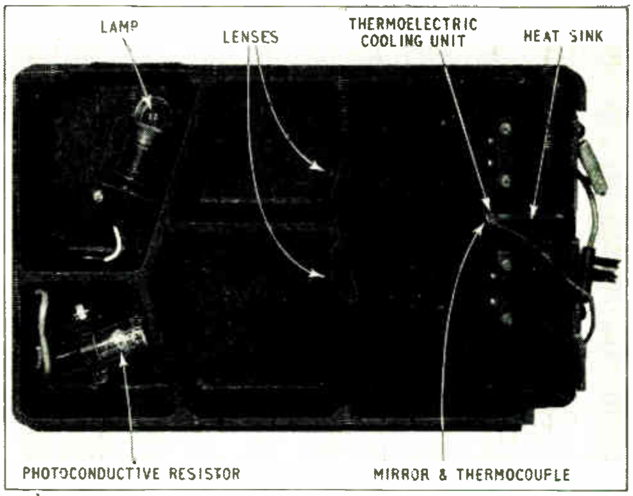


Fig. 1.—Schematic diagram of the automatic dewpoint hygrometer

instruments which incorporate thermoelectric cooling devices, and some of these will now be briefly described.

Automatic Dewpoint Hygrometers

These instruments are designed to provide automatic monitoring of the dewpoint of gases in closed circuits. One version is also designed for use in open atmospheres. A block schematic diagram of the instrument is shown in Fig. 1. A single-couple thermoelectric unit is used to cool a mirror, on which dew is formed when the dewpoint temperature is reached. Light scattered from the misted surface is focused on to a photoconductive cell and varies the input signal to a servo amplifier, which in turn controls the current applied to the thermoelectric cooling unit. The system, therefore, stabilizes the temperature of the mirror to the point at which a film of dew is just maintained on its surface; i.e., at dewpoint temperature. The temperature of the mirror is monitored by a copper–constantan thermocouple, and the accuracy of the dewpoint indication can be within ± 0·25 °C depending on the accuracy of the temperature recording instrument. The range of dewpoint temperature measurement extends down to 30 °C below ambient temperature. The photograph of the hygrometer head shows the thermoelectric cooling unit, the heat sink and the mirror and optical system.



Head unit for the S.E.I. automatic dewpoint hygrometer

Manually Controlled Hygrometer

This is a simple manually-controlled hygrometer designed for use in applications where the expense of the Automatic Dewpoint Hygrometer is not justified. This instrument consists of a mirror which is cooled by a thermoelectric cooling unit. The current to the cooling unit is manually adjusted to the point at which dew just starts to form on the surface of the mirror. The surface of the mirror is observed through a simple telescope, and the mirror temperature is monitored by a thermistor. The temperature of the mirror is registered on a direct-reading instrument. It is anticipated that this instrument may well be used as a replacement for the conventional wet-bulb thermometer, and may become widely used in meteorology and allied applications.

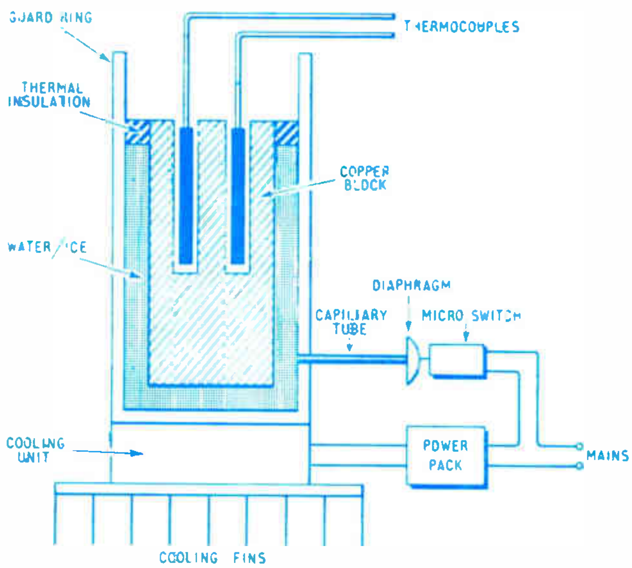
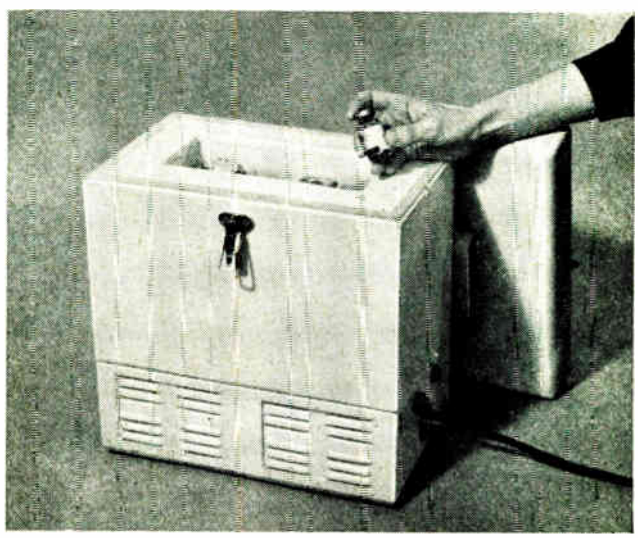


Fig. 2.—Schematic diagram of the 0 °C temperature reference cell

0 °C Temperature Reference Cell

The function of this cell is to provide a 0 °C reference temperature for use with thermocouples, as an alternative to the conventional ice bath. In this instrument the temperature of a quantity of water which completely fills a sealed copper cell is reduced to freezing point by means of a thermoelectric cooling unit, and the increase in volume caused by some of the water freezing is used to flex a diaphragm. The movement of the diaphragm operates a microswitch which breaks the supply to the cooling unit. This reverses the cycle, and the reduction in volume resulting from some of the ice melting allows the microswitch to close again. The cycle of operations repeats itself and so maintains a water-filled ice-shell inside the cell. A copper block which is thermally insulated from the walls of the cell is held in intimate contact with the water and is, therefore, held at the temperature of melting ice. The temperature of this block provides the 0 °C reference temperature. The cool-down time of this cell is about 30 minutes. The accuracy of the temperature reference is within ± 0·02 °C, but this may be improved by one order of magnitude in future models. A schematic drawing of this instrument is shown in Fig. 2.



Portable cold box with cover removed

Portable Thermoelectric Cold Box

The intended application of this box, which is shown in one of the photographs, is in clinical work for the storage and transportation of antibiotics, plasma, etc.; as well as for more obvious domestic purposes. The cooling system comprises two 12-couple cooling units, giving a nominal cooling power of 6 watts when operating at nine amps and 1·8 volts. The internal dimensions of the box are 9 in. × 6 in. × 4 in. When operating in an ambient temperature of 80 °F the air temperature inside the box is maintained at 39 °F. The time taken for the box to cool down to 90% of its maximum temperature depression is about 80 minutes. Time taken to recover to 90% of ambient temperature is about 90 minutes after switching off.

Conclusion

The development of thermoelectric cooling techniques has now passed into the production stage. Improved methods of manufacture and enhanced properties of materials are combining to lower prices and improve efficiency. Over the last twelve months a considerable reduction in price has been achieved and there is every reason to forecast that this trend will continue for several years. The application of thermoelectric devices to cooling problems involving low or moderate cooling powers appears to be limited only by engineering ingenuity or by failure to recognize their usefulness.

The author thanks Messrs. Salford Electrical Instruments Ltd. for permission to publish this article; Mr. D. Hallsworth for his assistance in the preparation of this article, and all members of the staffs of S.E.I. and G.E.C. Hirst Research Centre, who have been concerned with thermoelectric projects.

ROBOTUGS SPEED HANDLING OF SHOES

The first shoe manufacturing company in this country to introduce Robotugs for goods handling is Manfield and Sons Ltd., of Northampton. Two of these driverless tugs and a figure-eight track have been installed by E.M.I. Electronics Ltd. at Manfield's warehouse.

This industry suffers from a labour shortage and fashion peak periods necessitating the rapid movement of large quantities of shoes within the warehouse. It has been found that the Robotug system enables the same labour force to unload nearly four times as much incoming stock as before.

Several stopping points have been sited along the track so that a full Robotug train can be programmed at the goods-inward department to stop automatically within 4 yds of any spot in the warehouse. A tug can be called to any of these points by pressing a button, when the appropriate indicator lights up on a call display board in the packing department. The next tug to arrive there is then sent to the required point.

Each Robotug can haul three cage-trailers with a total capacity of 900 pairs of shoes in boxes. This is three times as many as a man can push.

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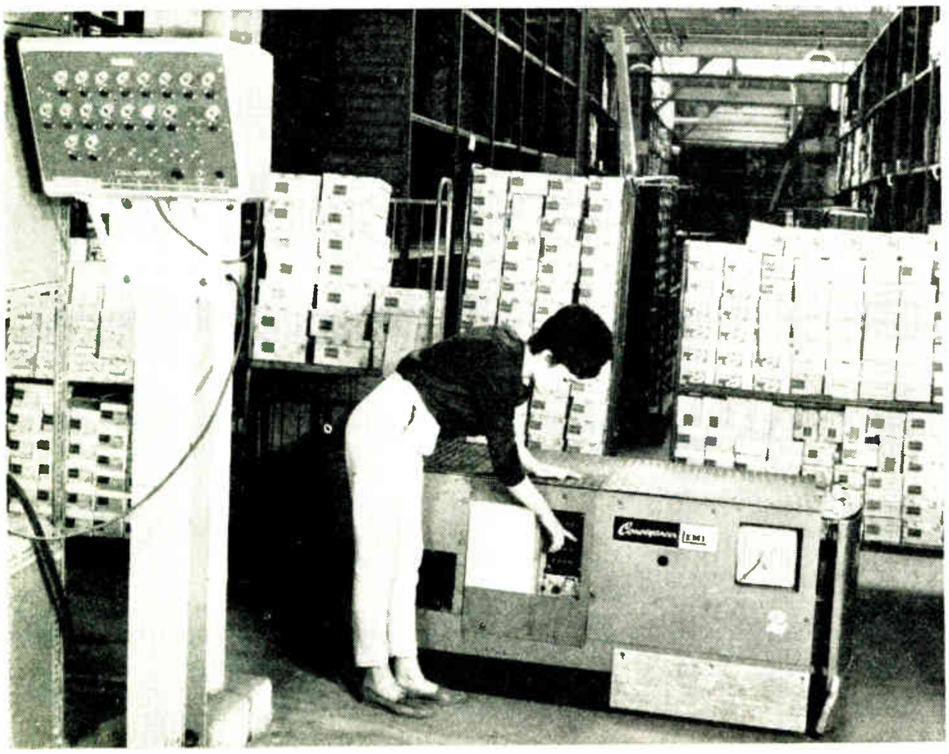


The picture shows an operator programming a Robotug to proceed to stopping point No. 15, which has signalled a request for a tug, as a result of which its indicator light has appeared on the call display board

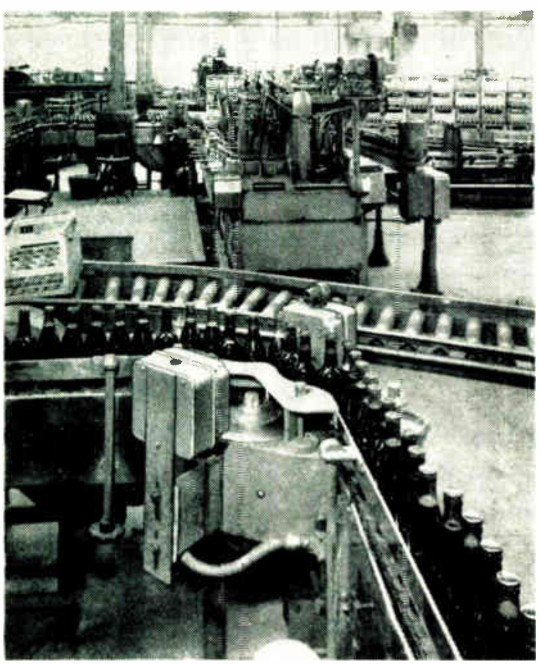
APPLICATIONS ILLUSTRATED

Photoelectric Devices

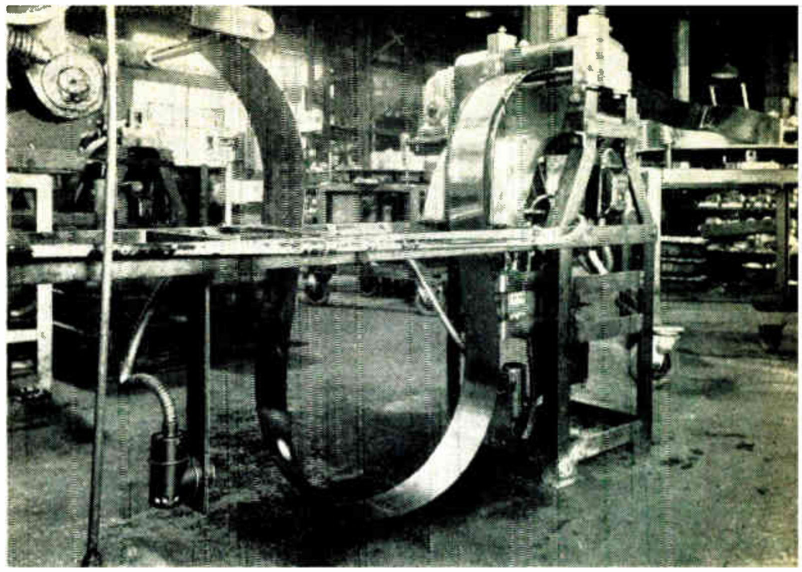
ONE of the most widely used electronic devices in industry is the photoelectric relay. The popularity of the photoelectric relay is primarily brought about by two features—simplicity in installation and operation and because the actuation does not depend upon physical contact with the article concerned.

The device comprises basically a light projector, photocell, amplifier and relay. In operation, light falling on the photocell produces an output which is amplified to operate the relay and produce an electrical switching action. This series of photographs illustrates some of the many applications of A.E.I. photoelectric relays.

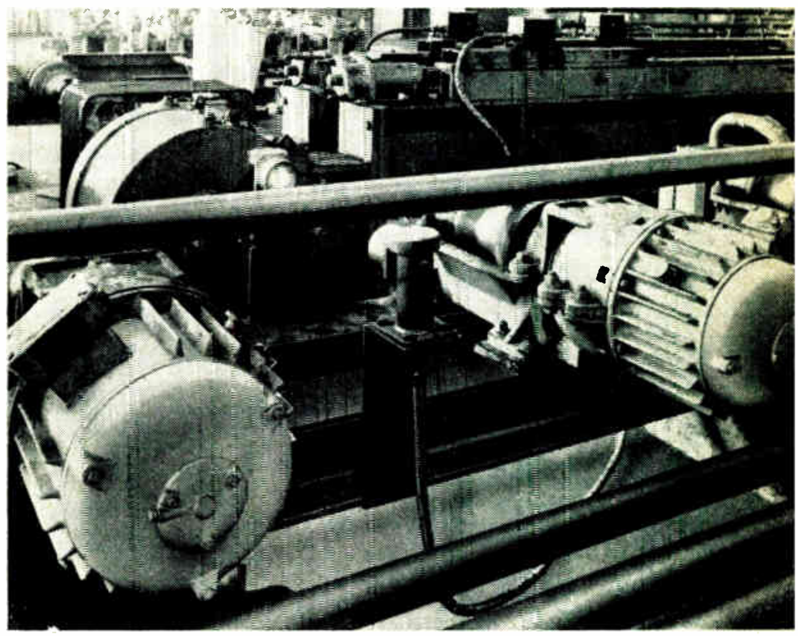
For further information circle 53 on Service Card



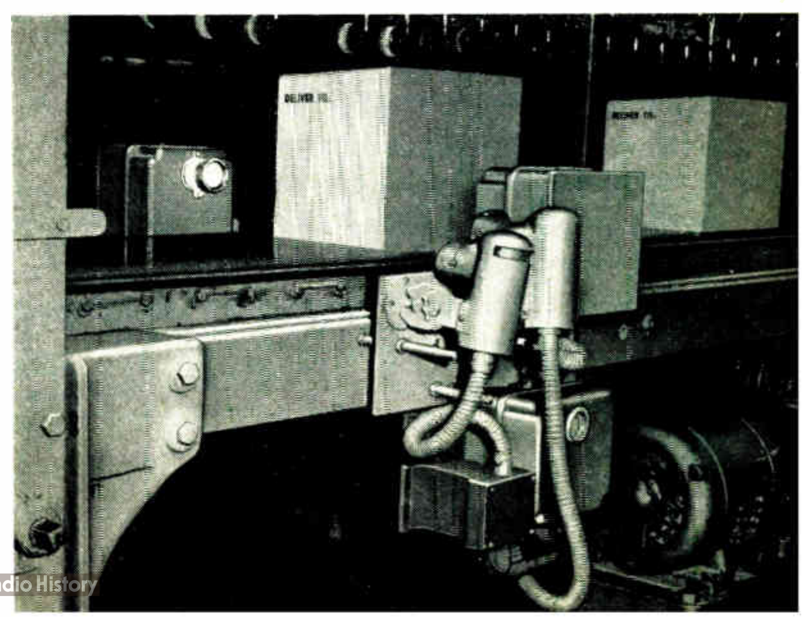
A simple bottle-counting application of the photoelectric relay



In this metal-strip process a photoelectric relay is used to control the speed of the metal. The tightening of the loop allows light from the projector to reach the photocell, while lengthening it interrupts the light beam; the relay is thus actuated or de-energized



Here the photoelectric relay is used as a limit switch in the production of metal rod



Control of a conveyor using two photoelectric relays. One indicates the presence of a carton, while the second sorts the cartons by colour discrimination

EQUIPMENT review

1. Turbidity Meters

PHOTOELECTRIC EQUIPMENT designed to monitor the turbidity of liquids in industrial processes, such as oils, beer, sugar and paper stock, has been designed and is now being manufactured by Hird-Brown.

The equipment, which is also capable of monitoring solids in water or gases and noting their content, comprises three basic units: a control fitted with a meter and alarm or recorder contacts; a light beam projector; and a photocell receiver.

The cell and projector are positioned on opposite sides of the liquid or gas flow and are connected electrically to the control unit. The control unit measures 18 in. by 15 in. by 9 in. and is provided with four lugs for wall mounting. Turbidity is indicated on the large dial of a clear face meter viewed through a safety toughened glass window. All components are underrated to give a long life, and all adjustment controls are accessible through a sealed door.

The equipment can be despatched within two to three months from the date of the order.—*Hird-Brown Ltd., 244 Marsland Road, Sale, Cheshire.*

For further information circle 1 on Service Card

2. Resistance Welding Control

A COMPLETE resistance welding control unit is now available from Lancashire Dynamo. Known as the Series GWC.2, the equipment comprises an ignitron contactor and four-stage synchronous timer installation and is primarily designed for gun welder control. It is also equally suitable for the control of pedestal-type spot-welding machines.

The timing unit provides synchronous control of the 'squeeze', 'weld', 'hold' and 'off' functions. Each of the timed intervals is independently adjustable from 0 to 109 cycles in one cycle steps and 'up slope' control can be switched into the circuit on the 'weld' interval. The ignitron contactor unit is designed to accommodate international size 'A', 'B' or 'C' ignitrons and heat control facilities provide for a 30:1 range of power control without tap changing, thus enabling the required heat to be adjusted within very close limits.

The control unit is equally suitable for one or two guns operating from a common transformer and the timing and heat controls are independently adjustable for the weld period of each gun. The units are also suitable for use with conventional and Hypersil welding transformers.

The complete installation is housed in a wall-mounting cubicle, the overall dimensions being 38 in. × 32 in. × 14 in.—*Lancashire Dynamo Electronic Products Ltd., Rugeley, Staffs.*

For further information circle 2 on Service Card

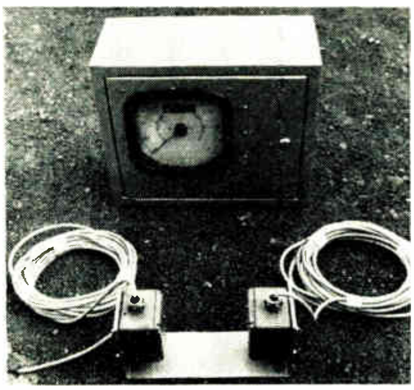
3. Bead Thermistors

GULTON INDUSTRIES are to market Glennite thermistors in the U.K. commencing with the series of bead thermistors.

The bead thermistors, which are normally glass coated, are available in all types and can be supplied with basic resistance values from 1 Ω to 1,000 MΩ in a wide range of temperature coefficients of resistance between −3·4%/°C and −6·8%/°C.

They are available in all power ratings and sizes, the smallest having a dissipation constant of 0·1 mW/°C with a diameter of 0·014 in.

All of the Gulton Glennite thermistors will operate continuously with maximum stability at temperatures up to 300 °C and some types are suitable



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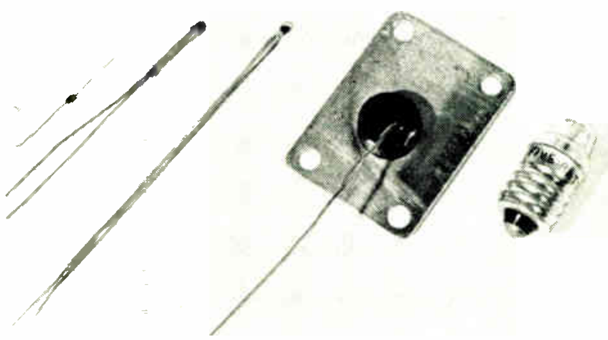

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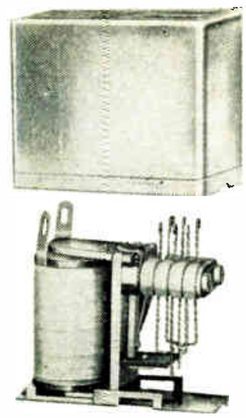

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for continuous use at 500 °C with only a slight degradation of performance.—*Gulton Industries (Britain) Ltd., 52 Regent Street, Brighton 1, Sussex.*

For further information circle 3 on Service Card

4. 'Datapulse' Generator

THIS IS one of a range of pulse generators and data generators made by Datapulse Incorporated, which are now available in the U.K. through Livingston Laboratories.

With applications in logic and circuit development, magnetic material study, telemetry and navigation system test and semiconductor evaluation, the 102 provides pulses of up to 50 V into 50 Ω at risetimes variable from 10 to 500 nanosec. Pulse width can be adjusted from 50 nanosec to 10 millisec and repetition rate is variable from 2 c/s to 3 Mc/s.

The pulse generator can be triggered externally at rates from 0 to 3 Mc/s by a 15-V positive pulse with less than 2 μsec risetime or from a 20 V r.m.s. sine wave from 200 c/s to 1 Mc/s.

Protection from overload is provided by a circuit which decreases the output to a safe level and operates a panel indicator lamp when the average output current exceeds approximately 225 mA. Removal of the overload automatically returns the circuit to normal.

Other features include single shot and sync output facilities and the instrument can be supplied in bench or rack-mounting versions.—*Livingston Laboratories Ltd., 31 Camden Road, London. N.W.1.*

For further information circle 4 on Service Card

5. 100 Mc/s Relay

DETAILS OF a low-capacitance relay are announced by Plessey. The relay is intended for r.f. switching at frequencies up to 100 Mc/s and has a capacitance between contacts of less than 0·5 pF, with contact-to-frame capacitance less than 1 pF. Contact rating is 5 mA at 200 V with a life of more than 10^6 operations. The self-cleaning, silver-palladium wire contacts are arranged to give two-pole changeover switching and can be used at switching rates up to 25 c/s. Designed for d.c. operation, the coil can be supplied in a wide range of operating voltages and resistances to suit individual requirements. A useful feature of the relay is its short operating time of 6 msec. The unit is housed in a transparent dust cover, overall dimensions $1\frac{1}{8}$ in. × $1\frac{17}{32}$ in. × $\frac{3}{4}$ in.—*The Plessey Company (U.K.) Ltd., Industrial Relays Division, Abbey Works, Titchfield, Fareham, Hampshire.*

For further information circle 5 on Service Card

6. A.E.I. Wall Telephone

A WALL TELEPHONE Type 980 has been added to the A.E.I. Centenary Neophone range of telephone instruments. The telephone is available for export and is also suitable for use with private telephone systems and other intercommunication equipment already using telephones in the A.E.I. Centenary range. It is made as either a short-line or short/long-line instrument for use with subscriber telephone circuits of up to 1,000 Ω loop resistance.

The telephone, when mounted, projects less than 4 in. from the wall. Moulded in impact resisting thermoplastic material, it is a sturdy instrument with clean lines and a minimum of dust-trapping ledges. Standard colours for the case are black, ivory and grey, and for the handset black, ivory, dark grey, maroon, red and green.

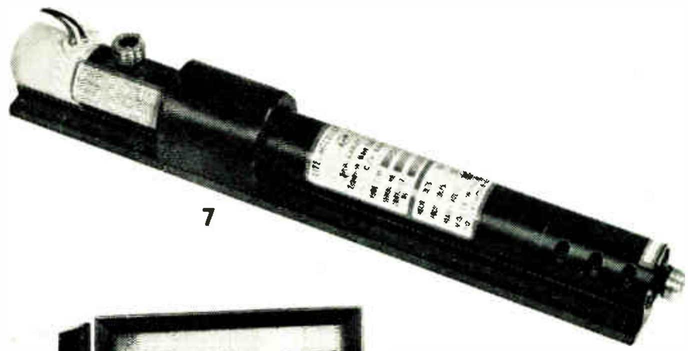
The dial, the latest trigger type, is normally fitted with a stainless steel finger plate, but a p.v.c. plate can be fitted if preferred. Dial markings can either be supplied on a character ring surrounding the dial, or provided on a ring, visible through the holes in the finger plate.—*Associated Electrical Industries Ltd., Telecommunications Division, Woolwich, London, S.E.18.*

For further information circle 6 on Service Card

7. Eimac kMc/s T.W.Ts

A RANGE OF travelling-wave tubes with some unique performance factors has been introduced by Eitel-McCullough Inc., U.S.A. Sixteen different types are available with frequencies in the range 2 to 12 kMc/s, powers of 0·5 to 5 W, gains of 30 to

EQUIPMENT review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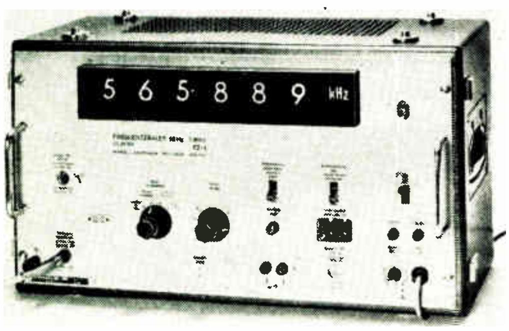

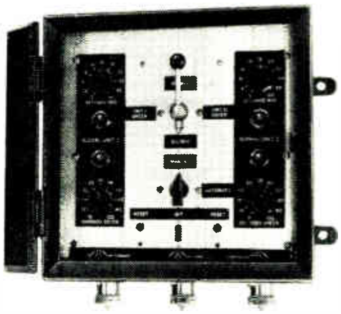
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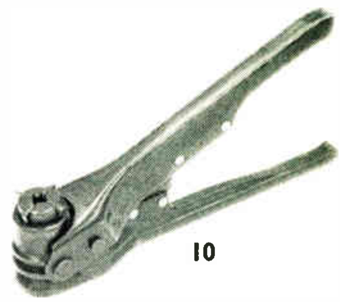
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60 dB. Features for these tubes include wide bandwidths (e.g., one tube, type EM1060, covering the range 2·5 to 11 kMc/s), high gain (up to 60 dB), ruggedness (25*g*, 11 msec shock; 20 *g* vibration), wide operating temperature range (−55 to +72 °C) and ceramic/metal construction.—*Walmore Electronics Ltd., 11-15 Betterton Street, Drury Lane, London, W.C.2.*

For further information circle 7 on Service Card

8. 1 Mc/s Frequency Counter

ELLIOTT BROTHERS announce that Wandel and Goltermann have recently started production of a frequency counter type FZ-1 which incorporates many useful refinements. This includes a buffer store which automatically holds the display during a counting period, and switch selection of frequency or inverse frequency.

The instrument is fully transistorized, and covers a range of 10 c/s to 1 Mc/s; a convertor unit for measurements up to 20 Mc/s will be available shortly. The counter may be powered by a wide range of mains or battery voltages and will automatically change over to battery operation in the event of a mains failure. Other useful features include a large clear display, provision for direct reading of frequency ratios, or use with an external standard frequency, print out facility, and a very wide signal input voltage range.—*Elliott Bros. Sales Agencies Ltd., Elstree Way, Borehamwood, Herts.*

For further information circle 8 on Service Card

9. Traffic Signal Controller

FOLLOWING A long period of investigation in co-operation with users of road traffic signal equipment, Contronics have introduced a portable semiconductor traffic signal controller.

The controller is intended to operate two or more sets of traffic control lights and is designed for two-phase working with four separate timing cycles which may be independently adjusted in fixed steps. Based on the recommendations of the Ministry of Transport, each red phase can be adjusted from 3 sec to 60 sec and each green phase from 5 sec to 100 sec. This gives a total time cycle which is adjustable from 16 to 320 sec with a timing accuracy of $\pm 7\frac{1}{2}\%$.

The unit will accept any voltage between 12 and 28 a.c. or d.c.

The four timing units are connected in cascade, each timer providing an output to the following timer when it has completed its set time. The last timer in the chain operates a re-set circuit which first re-sets all timers and then initiates the first one again. The outputs from the timers are combined by a logic switching circuit to operate the two relays which switch the heavy current to the signal lamps.

The electronic circuits are split into separate plug-in units for ease of servicing and are compensated against changes in temperature to give an operating range from 0 to 45 °C.

The controller is housed in a robust weather-proof steel case size 12 in. × 12 in. × 6 in. fitted with hinged door and lock.—*Contronics Ltd., Garth Works, Deepcut Bridge Road, Blackdown, Nr. Aldershot, Hants.*

For further information circle 9 on Service Card

10. Multi-Size Crimping Tool

HELLERMANN DEUTSCH have announced the introduction of a compression tool for crimping pins and sockets for HAN Bambi, Deutsch and most other connectors of standard specification.

This tool covers a wide range of connectors and will double dimple crimp conductors of the following sizes without changing any dies or stops: 16, 18, 20, 22, and 24 a.w.g. and DEF 12 14/0076, 14/0048, and 7/0076.

This tool has interchangeable locators which cover various makes of connectors and a wide variety of conductor sizes.—*Hellermann Deutsch Ltd., Gatwick Road, Crawley, Sussex.*

For further information circle 10 on Service Card

11. Precision Teflon Film Capacitors

TEFLON film capacitors are now available from Salford Electrical. Types TA and TF are designed for operating in the temperature range from −62 °C to 125 °C. Both types will meet the vibration and shock test per Mil-C-25 A or Mil-E-5272 and all applicable specifications relative to corrosion humidity and moisture resistance per Mil-C-25 A.

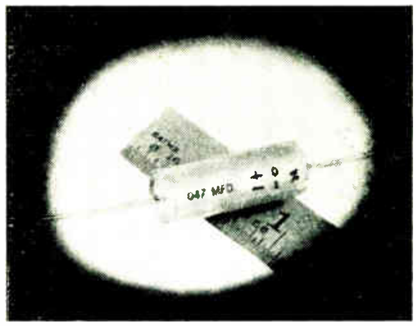
The high order of electrical and mechanical stability makes the TA suitable for use in circuits subject to wide temperature variations and severe environmental conditions, where low capacitance deviation and minimum drift are required.

The type TF, made from FEP fluorocarbon film, offers excellent performance at reduced cost. Designed for network and tuned circuit applications the TF deviates less than 1·5% from ambient over the temperature range.

An inherent feature of both types of capacitors is their ability to withstand safely momentary overload of several times their rated voltage.

The capacitors are hermetically sealed in tin-plated brass cases.—*Salford Electrical Instruments Ltd., Peel Works, Silk Street, Salford 3, Lancs.*

For further information circle 11 on Service Card



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12. Component Testing Controller

AVELEY ELECTRIC have produced a range of self-contained control units for use with existing measuring equipment.

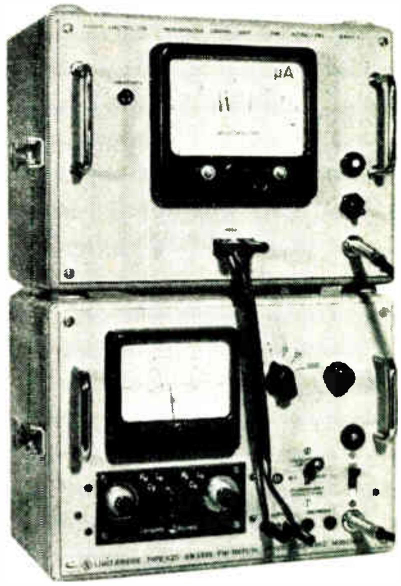
The illustration shows one of these units used in conjunction with the Rohde & Schwarz Limit Bridge type KZS.

The direct reading of component comparison against standards by the KZS, combined with continuously variable (between two pre-set pointers), upper and lower limit indication, and control of rejects by the Avel Controller provides a highly efficient automatic system for quality control engineers. By the addition of a further unit now under development by Aveley Electric, a statistical analysis of actual errors in both rejects and accepted items, or the pre-selected sorting into as many as 14 groups, will be possible.

The control unit which is built around a two-limit Gossen Mess-contactor, comprises a dual transistorized amplifier and twin relays each fitted with two pairs of heavy duty changeover contacts and wired to a six-point terminal block. A power supply is incorporated to operate on an input of 115 or 230 V a.c. at 40 to 100 c/s.

The control unit is easily adapted to all kinds of existing equipment and to continuous servo control of process as well as to upper and/or lower limit indication. Left-hand and centre-zero meters of various sensitivities and calibrations are available.—*Aveley Electric Ltd., South Ockendon, Essex.*

For further information circle 12 on Service Card



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13. Miniature Relay

B. & R. RELAYS have designed a miniature dry-reed relay known as the RO.5—it is the smallest relay in their range to date. The main body of the relay is 1-in. long and $\frac{11}{32}$-in. diameter. The maximum overall length including connector wires is 2½ in. It has one normally-open contact.

Due to its small size, sensitivity and speed of operation the RO.5 offers designers a compact and economical relay which will find ready operation in data processing, communications and industrial process control.

The RO.5 is based on a Gordos miniature dry-reed switch, the M.R. 400-1. This has a glass length of 0·875 in. and diameter of 0·095 in.; initial contact resistance is between 60 to 200 mΩ. Life expectancy is 3 million operations rising to 20 million at low load. The whole relay is enclosed in steel tubing, which acts as a screen preventing interaction between adjacent reeds.

The standard coil is suitable for voltages up to 30 V d.c., but composite windings for higher voltages are available. The nominal operating power is 132 mW. The contact is rated at 4 W at a maximum of 0·125 A and 250 V; the RO.5 has a total operating speed of 1·5 to 2·5 msec; the bounce time is less than 200 μsec.

In quantities in excess of 200 relays the RO.5 in standard coil version is priced at under 13s. each.—*B. & R. Relays Ltd., Temple Fields, Harlow, Essex.*

For further information circle 13 on Service Card

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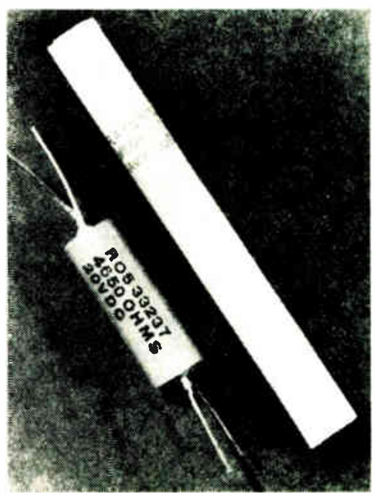

14. Improved Taylor Multimeter

THE TAYLOR Model 88A has now been considerably reduced in size without sacrificing the performance and very large number of self-contained ranges. The instrument is now available in either a bakelite or wooden case and is known as Model 88B.

The features of the 88A have been

retained, including the sensitivity of 20,000 Ω/V, resistance ranges up to 50 MΩ (with incorporated batteries), mirror scale, decibel and output readings, capacitance and inductance measurements. The overload protection is also retained, but is now in the form of a mechanical cut-out. The model 88B also incorporates a reverse polarity facility. The scale is calibrated in three colours to facilitate identification of ranges.

The large number of incorporated ranges facilitate more accurate readings as it is possible to utilize full-scale deflection for most measurements. The instrument is extremely robust in construction and a rugged high-grade Taylor moving-coil centre-pole meter is fitted.

Accessories include a high-voltage probe for measurements up to 25 kV (model 488), an inductance-capacitance adaptor model 388, and a leather carrying case.—*Taylor Electrical Instruments Ltd., Montrose Avenue, Slough, Bucks.*

For further information circle 14 on Service Card

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review

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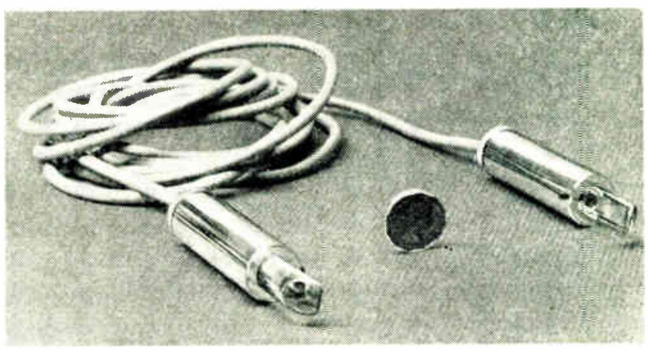

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15. Helical Potentiometer

FOLLOWING the introduction of their HEL 07-10 helical, 10-turn potentiometer Reliance Controls are now producing a 5-turn version designated HEL 07-05.

Physically it is shorter than the 07-10 having a body length of $1\frac{3}{8}$ in. (34·9 mm) as against 2 in. (50·8 mm), but the body diameter remains the same at $\frac{3}{4}$ in. (19 mm).

Models are available with total resistance values from 50 Ω to 25 kΩ. For potentiometers up to 15 kΩ the basic law accuracy is ±1% or better to within ±0·25%; this is reduced to ±0·5% for models with total resistance values above 15 kΩ. Other models with resistance values of less than 50 Ω are available to special order.—*Reliance Controls Ltd., Relcon Works, Sutherland Road, London, E.17.*

For further information circle 15 on Service Card

16. Immersion Thermostat

R. B. PULLIN announce the introduction of a high-temperature version of their H8 immersion thermostat.

The new model, H8/11FH, has a temperature range of 150 °F to 250 °F (or H8/11CH, 65 °C to 120 °C). The stem length is 11 in., the differential is 8 to 15 °F or 4·5 to 8·5 °C, and the list price is 25s.

The temperature ranges of the standard 7 in. and 11 in. H8 thermostats have also been increased as follows: H8/7F 7 in. stem 30 °F to 190 °F (H8/7C 0 °C to 87 °C); H8/11F 11 in. stem 90 °F to 190 °F (H8/11C 32 °C to 87 °C).—*R. B. Pullin & Co. Ltd., Phœnix Works, Great West Road, Brentford, Middlesex.*

For further information circle 16 on Service Card

17. Miniature Projectors and Photocell Receivers

A MINIATURE projector and receiver have been produced to operate this firm's range of photo-electric cell operated relays.

The projector and receiver are identical in appearance, each measuring $2\frac{1}{8}$ in. × $\frac{3}{4}$ in. and complete with a 5-ft length of twin cable for connection to a suitable junction box. The projector is fitted with a 6-V, 0·9-W lamp with a lens system to produce a beam suitable for use up to 12 in. from the receiver.

Standard control units include a low voltage transformer for supply to the projector, which is underrun for long life. The receiver is also fitted with a lens system to focus light on to the photo-transistor, thereby ensuring reliable operation. The ambient temperature range is −20 °C to +35 °C. The price of the units is

90s each, delivery ex stock.—*Hird-Brown Ltd., 244 Marsland Road, Sale, Cheshire.*

For further information circle 17 on Service Card

18. Miniature Solenoids

TWO MINIATURE d.c.-operated solenoids, Types TLA.14874 and L.2272, are now being produced by Plessey. An unusual feature of the Type TLA is that it incorporates a fine adjustment of stroke which makes it particularly suitable for applications in precision apparatus. With a 20 to 24-V d.c. supply the operating current is 100 mA. A pull of 50 gm can be obtained and the operating time at this load is better than 6 millisec. With an insulation, at 250 V d.c., of 10 MΩ, this solenoid weighs approximately 14 gm.

The second solenoid, the Type L, is a reverse action fixed-stroke unit. With a supply voltage of 60 V d.c. and operating on a current of 250 mA a push of 60 gm through 7 mm is obtained. This unit has a weight of approximately 50 gm.—*The Plessey Co. Ltd., Ilford, Essex.*

For further information circle 18 on Service Card

19. Silicon Rectifier Motor Control

A LOW COST motor speed control unit, utilizing the silicon controlled rectifier in a fully transistorized arrangement, has been developed by Lancashire Dynamo to provide a wide variable speed range for industrial applications where high performance is required.

This unit, known as the Series SRD.1 'Stardrive', provides stepless control over a speed range of 20:1 and maintains good regulation of the set speed in the presence of fluctuating loads. The equipment is available in $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$ and 1 h.p. ratings.

Alternative features include reversing, dynamic braking, and remote control facilities.

Using semiconductor components exclusively, the 'Stardrive' has been designed for continuous industrial duty with great reliability in operation. Full electrical protection is included and the equipment can be handled by completely unskilled personnel without risk of damage due to mishandling. —*Lancashire Dynamo Electronic Products Ltd., Rugeley, Staffs.*

For further information circle 19 on Service Card

20. Transistor Millivoltmeter

ONE OF THE latest portable measuring instruments from Dawe is the type 616A Transistor Millivoltmeter. This is designed for the measurement of alternating potentials from less than 1 mV to over 300 V over the frequency range of 2 c/s to 100 kc/s. The meter has ten switched ranges from 10 mV f.s.d. to 300 V f.s.d. and the input resistance varies from 5 MΩ for the five least sensitive ranges to 100 kΩ for the most sensitive range. The accuracy is better than $\pm 2\%$ at f.s.d. on all ranges, with a sinusoidal input at 1 kc/s.

As the instrument is battery operated and truly portable it is particularly suitable for field work where no external power source is available.—*Dawe Instruments Ltd., Western Avenue, London, W.3.*

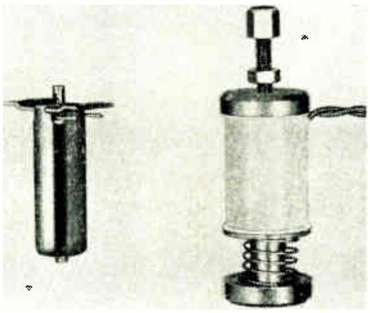
For further information circle 20 on Service Card

21. Miniature Potentiometric Recorders

FOUR-IN. single-trace and multi-point potentiometric recorders, Types 4S and 4M respectively, have been introduced by A.E.I. For measuring and recording any quantity which can be presented as a low level d.c. signal, they have a specification and performance equal to conventional 10-in. recorders. The multi-point recorder, the first miniature recorder to be introduced with multicolour printing, will accept signals from 2, 3 or 6 channels simultaneously and record the value from each channel in a different colour on the 4-in. chart. Both units have an absolute accuracy, under recommended operating conditions, of $\pm 0{\cdot}5\%$.

The recorders are designed primarily for industrial use, but also provide the accuracy required for scientific applications. The new instruments need a panel cut-out of only 6 × 6 in.

Chart speeds from $\frac{1}{2}$ in. to 3,600 in. per hr can be obtained, in four ranges, with the Type 4S recorder, and two separate speed coverages can be obtained by fitting two motors in a single recorder. The Type 4M multi-point recorder, with chart speeds from



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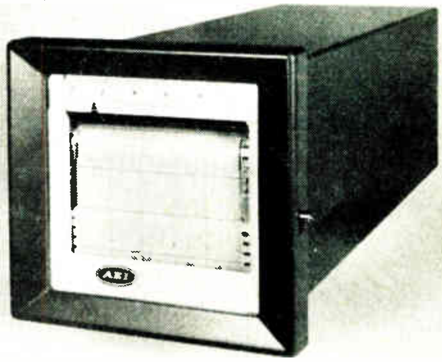

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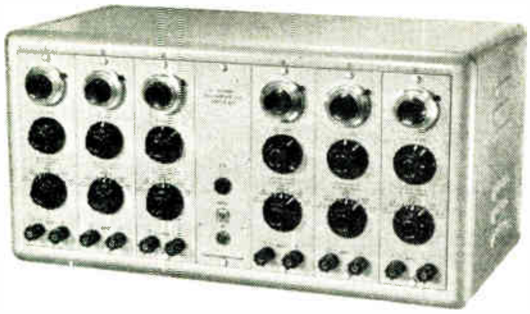
EQUIPMENT review



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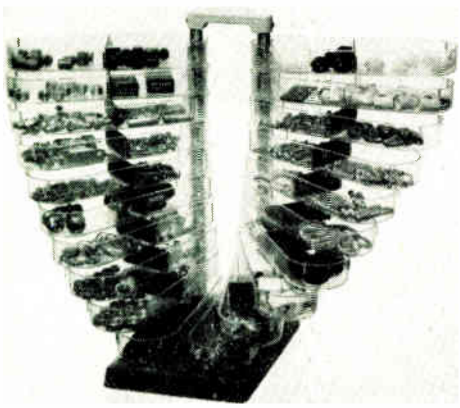

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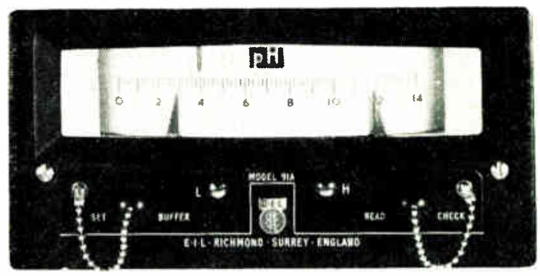

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½ in. to 72 in. per hr, has a printing speed of 1 point per 5 sec or 1 point per 10 sec, according to the type of motor fitted.

Standard millivolt spans are 1, 2, 5, 10, 20, 50, 100 and 200. Various degrees of zero suppression are available.—*Associated Electrical Industries Ltd., Instrumentation Division, P.O. Box 1, Harlow, Essex.*

For further information circle 21 on Service Card

22. 6-Channel D.C. Amplifier

A TRANSISTORIZED 6-channel d.c. amplifier, comprising six compact, highly stable transistorized d.c. amplifiers, with a common stabilized power supply, has been introduced by Experitron. This has been designed primarily to enable strain gauges, thermocouples, pressure transducers, etc., to operate recording galvanometers and similar instruments.

Each of the six channels has a 'set zero' control and the output, which is balanced about earth, may be switched to positive or negative polarity, and channels may be added or omitted as required.

The unit may also be incorporated in process control systems where signals from transducers have to be amplified to a usable level.

The basic amplifier units can be fitted with various input and output attenuators and terminations to suit individual requirements. Where necessary, suitable pre-amplifiers (down to 2 mV maximum input) can also be incorporated.

Maximum input is 100 mV; input impedance 1 kΩ at maximum sensitivity; output impedance 50 Ω. Maximum output current is 35 mA; linearity, better than 2%, and frequency response d.c. to 10 k/cs at −3 dB. Drift is 10 millimicroamps per °C.

The power supply required is 200–240 V, a.c., 50 c.p.s.

Overall dimensions of the unit are, 21 in. × 11 in. × 12 in. deep, and the basic price of a 6-channel instrument is £300.—*Experiton, 165 Young Street, Sheffield.*

For further information circle 22 on Service Card

23. Visipart Tray Stacks for Assembly

THIS POPULAR, versatile unit, built up on aluminium tube pillars, now has a plastic carrying handle, which makes it easy to pick up and transport, an attractive, redesigned stable base, moulded in pale blue, high impact polystyrene, and 20 transparent plastic trays, each of which may be divided by a removable partition, to form up to 40 separate compartments.

The transparent trays can be swivelled through an arc of 350°. When not in use, the trays are stacked 'in line', to reduce bench space required to 9½ in. × 6¼ in. (height 15 in.).

A special feature of this unit is the speed with which, at a glance, the contents of each tray and compartment, may be noted, and that particular tray then fanned out, at finger tip control, to expose its contents. Damaged trays may easily be removed and replaced very quickly.

The 'Visipart' is ideal for all assembly work where many small component parts need to be stored, but are required at-a-glance, particularly for instrument, electrical, radio and T.V. assembly, and it is also being used by manufacturers of everything from buttons to seeds and fertilizers.

An alternative pattern, known as the 'Ministak', comprising 12 loose, removable trays, held in a wire frame —which complete assembly may be rested on top of or adjacent to similar

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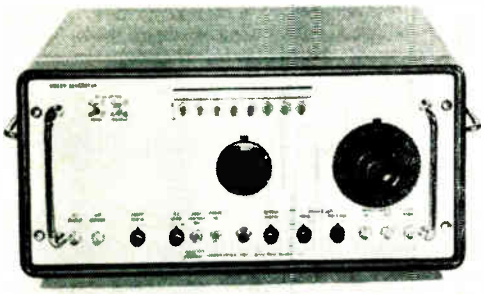

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units—is also available.—*British Central Electrical Co. Ltd., 6 & 8 Rosebery Avenue, London, E.C.*1.

For further information circle 23 on Service Card

24. Industrial pH Meters and Controllers

ELECTRONIC INSTRUMENTS announce their Model 90 Series of miniature industrial pH meters and controllers. The Model 90 Series provides a complete pH meter-controller with adjustable upper and lower limit controls, accommodated within the confines of a standard edgewise indicating meter.

The Model 90 Series is supplied in panel mounting cases which conform to the standard Continental DIN sizes.

There are at present three instruments in the range—the Model 90A, which is a pH meter only; the Model 91A which is a combined pH meter-controller, and the Model 92A which is a general purpose controller, for use with any instrument having an output of 1·4 mA full scale.

The Model 90A pH meter covers the normal 0 to 14 pH range with an accuracy of better than 1% of full scale, and the stability over a 24-hr period is ±0·1 pH. Semi-automatic temperature compensation is provided together with a recorder output. The instrument operates from the usual mains supplies or from a special 12 V d.c. battery.

The Model 91A pH Meter-Controller has an identical specification but carries, in addition, upper high and low limit alarm contacts which can be adjusted over any part of the pH scale. These contacts actuate built-in relays capable of handling an external current of 2 A.

For use with the Model 90 Series, special industrial dip and flow type electrode systems have been designed, which are suitable for temperatures up to 70 °C.—*Electronic Instruments Ltd., Lower Mortlake Road, Richmond, Surrey.*

For further information circle 24 on Service Card

25. Digital Voltmeter and Ratiometer

BLACKBURNS' 5-digit Voltmeter and Ratiometer now has an accuracy of ±(0·005%+1 digit) of full scale. This instrument, the BIE.2116 Mark II, will measure voltages in the range ±10 μV to ±100 V d.c. with automatic range changing on all but the most sensitive range, which is selected manually. With the addition of the compatible AC-DC Converter BIE.2171, measurements may be made of alternating voltages of 1 mV to 1,000 V, in the frequency band 25 c/s to 100 kc/s.

The conversion time of the BIE.2116 is 105 msec maximum; sampling rates are variable from 1 per 2 seconds up to 5 per second, and a manual sample facility enables readings to be made at the touch of a switch, or by a trigger from an external source. Print-out facilities are available in decimal code for operating write-out devices.

The instrument measures 9¾ in. × 16½ in. × 15 in. and is available as a free standing or as a 19-in. standard rack mounting model. The weight is 54 lb. —*Blackburn Electronics Ltd., Brough, Yorks.*

For further information circle 25 on Service Card

26. 1,200 Mc/s Sweep Generator

A SWEEP GENERATOR is now available covering a wide spectrum of radio frequencies with a sweep width over its entire range. The instrument, Model SP-1200, manufactured by Telonic Industries Inc., U.S.A., has a centre-frequency range of 5 Mc/s to 1,200 Mc/s and a sweep width also 5 Mc/s to 1,200 Mc/s.

The instrument is well suited for either narrow or broad-band applications. A built-in detector and attenuator are designed for wideband performance so that the detected response maintains a uniform level over the entire range. An a.g.c. circuit continuously samples the swept output to assure this signal level. The response is level within ±0·2 dB over a 100-Mc/s width and within ±0·75 dB overall.

The SP-1200 has an r.f. output of over 0·25 V r.m.s. into 50 Ω that can be adjusted by a built-in turret attenuator in steps of 0, 10, 20, 30, 40 or 50 dB.—*Livingston Laboratories Ltd., 31 Camden Road, London, N.W.*1.

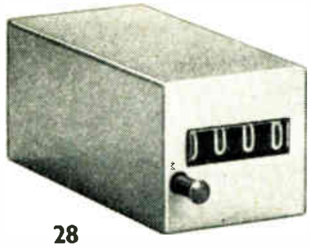
For further information circle 26 on Service Card

27. Miniature Magnetic Recorder

THIS PORTABLE, battery-operated instrument has been designed to Ministry specifications by Southern Instruments and is now scheduled for quantity production. It is suitable for use in mobile and airborne applications and under other arduous conditions.

The tape transport is constructed on an alloy casting and measures 9 × 9 × 6 in. overall. It will accommodate 500 ft of tape having a 0·001-in. base, and up to sixteen channels can be recorded on 1-in. tape; spools for ¼- and ½-in. tape are also available. A

EQUIPMENT review



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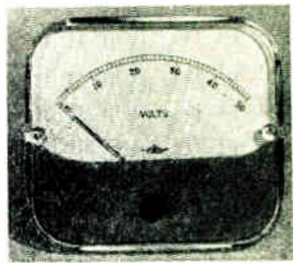

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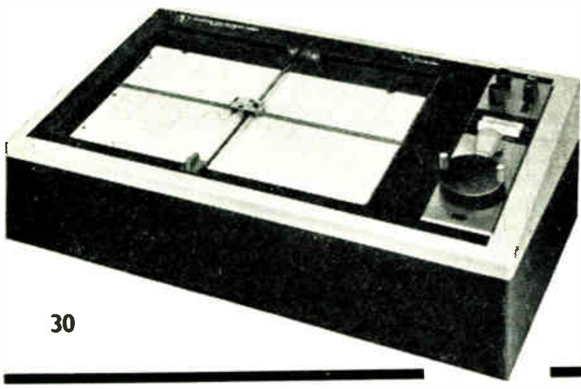

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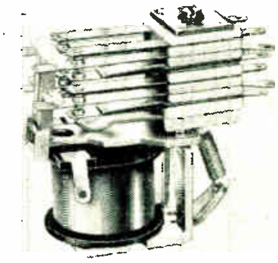

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closed loop tape drive control technique holds wow and flutter to a low order. The general performance is comparable with that of the SIRDL standard rack mounting range.

Features include push-button controls, provision for remote control, tape sensing for re-cycling and auto-stop, and a range of tape speeds.

The associated miniature record/replay units are fully transistorized and are available for direct, frequency modulation and digital recording.—*Southern Instruments Ltd., Instrumentation Division, Camberley, Surrey.*

For further information circle 27 on Service Card

28. Miniature Magnetic Counter

A MINIATURE magnetic counter by Veeder-Root has just been introduced. This unit solves the problem of a counting installation within a very limited panel area, and still provides exceptional figure legibility. This feature is further enhanced by the use of a magnifying crystal. The counter which is 2·4 in. × 1·125 in. × 1 in. makes a suitable unit for group or line mounting for control panel installations. Rear mounting is by 2 to 4 screws. Side leads or combination solder and plug-in terminals at the rear can be provided.

The counter which is specified to operate at 1,000 c.p.m. has a consumption of 1·5 W at 600 c.p.m. and 2·0 W at 1,000 c.p.m. Count life is estimated at a minimum of 20,000,000 without any lubrication and continuous duty coils are used.

Reset or non-reset versions are available with 3- or 4-figure capacity. The reset is instantaneous by push-button. —*Veeder-Root Ltd., New Addington, Surrey.*

For further information circle 28 on Service Card

29. Colour-Coded Meters

FOLLOWING the introduction of colour coding to their CY range of measuring instruments last year, Measuring Instruments (Pullin) Ltd. have added this development to their clearview plastic cased 35 T range. The colour-coded section which covers the whole of the lower face of the instrument is available in a standard range of colours including red for small quantities, though of course for bulk orders special colours can be supplied. The 35 T which has a $3\frac{1}{2}$-in. scale and can be fitted with a moving-coil, moving-iron or internal-magnet moving-coil movement is $4\frac{5}{16}$ in. across by $4\frac{1}{8}$ in. high. It can be supplied in a wide range of voltmeters up to 1,000 V and as an ammeter up to 60 A. Dynamometers wattmeters are also available in this range.—*Measuring Instruments (Pullin) Ltd., Winchester Street, Acton, London, W.3.*

For further information circle 29 on Service Card

30. Servo Recorders

THE HOUSTON Instrument Corporation models HR-80 and HR-87 T-Y recorders, which are now available from Scientific Furnishings, feature maximum convenience in recording and are designed to replace conventional strip chart and circular chart recorders for all applications where a chart length of 10 in. or 15 in. will provide adequate resolution. Records on standard graph paper are immediately available for use, reproduction or filing in standard loose-leaf notebooks. Controls permit several parallel records to be run on one chart for comparison. The model HR-80 is designed for $8\frac{1}{2} \times 11$ in. graph paper and the model HR-87 for $11 \times 16\frac{1}{2}$ in. paper.

Both the HR-80 and the HR-87 T-Y recorders include a null-seeking servo which moves an ink pen in proportion to a low-level d.c. input signal on the vertical axis and an inexpensive plug-in synchronous timing motor to move the pen from left to right on the horizontal or X axis. Separate power, standby and time-drive switches are provided. Stock motors provide many ranges from 10 sec to 15 min full scale. Motors up to 24 hr are available. Accuracy is 0·5% static or at constant velocity to 7 in. per sec on the Y axis. Input impedance is 10 kΩ or is near infinite with attenuator jumper removed.—*Scientific Furnishings Ltd., Poynton, Cheshire.*

For further information circle 30 on Service Card

31. Electrolube Grease

THE WELL-KNOWN mechanical and electrical lubricant Electrolube is now available in the form of grease. It is being sold in handy pocket-sized capsules.

Electrolube Grease No. 2G cannot melt, dry or harden, being extremely fine particle-sized grease of a new composition. It has an extensive working temperature range from −70 °C to above 200 °C. It is suitable for use where there are adverse weather conditions.—*Electrolube Ltd., Slough, Bucks.*

For further information circle 31 on Service Card

32. Low-Cost Relay

ROBINSON & CO. have produced a low-cost general purpose relay. The standard mains model will operate over the range of 180 to 250 V without a coil change.

It can have 2, 3 or 4 change-over contacts rated at 2 A 440 V, 6 A 250 V, and 10 A 50 V a.c. (non-inductive).

They are available from stock with the standard mains coil, but can be supplied with coils for any other supply in quantities of not less than 100.

The temperature rise does not exceed 45 °C, despite the wide voltage range, and it will stand a 2-kV proof test and life tests of 10 million mechanical operations.

List prices are as follows: 2 c/o 14s 6d, 3 c/o 18s 9d, 4 c/o 21s.—*D. Robinson & Company Limited, 5/7 Church Road, Richmond, Surrey.*

For further information circle 32 on Service Card

33. Stabilized Power Units

THE LEXOR stabilized power units models LT.12-05 and LT.24-05 are now available as Mk. III versions

Features incorporated include a much reduced noise factor and an improved overload and short circuit protection.

Two models are available: the LT.12-05 having an output voltage range of 5·5 to 14 V and the LT.24-05 having a range of 18 to 28 V. The output voltage of either instrument is continuously variable and may be adjusted either by a panel knob or a pre-set control. Both instruments will deliver output currents up to 0·5A continuously at all voltage settings. Regulation is better than 0·15% for ±10% mains-voltage change and/or zero to full load. Output impedance is not greater than 0·04 Ω and ripple is less than 2·5 mV peak.

The units are mounted in steel instrument cabinets 8 in. × 5 in. × 5¾ in. finished in grey hammer stove enamel with contrasting blue panels.

The price of the new Mk. III units is £25 7s.—*Lexor Electronics Ltd., 25/31 Allesley Old Road, Coventry.*

For further information circle 33 on Service Card

34. Switchboard Power Supply

A THREE-IN-ONE power supply designed for small telephone and intercommunication switchboards has been announced by Raytheon Co. of the U.S.A.

The modular construction of this model PABX combines a Raytheon 'Rectifilter' battery eliminator with a ringing generator and tone generator, all of which are available as single units. An applied load with a closed-loop magnetic amplifier improves regulation to below ±1%, permitting the unit's use as a battery charger for operations that require battery standby power.

Output of the solid-state PABX is 51·6 V d.c. at 6 A with a maximum ripple of 30 mV. Its ringing generator is rated at 80 to 125 V r.m.s. at 20 c/s and 7·5 W with a superimposed reverting tone. The tone generator is rated at 0·25 to 9 V r.m.s. and 600/120 c/s and 25 mW.—*Sorensen-Ard, A.G., Eichstrasse 29, Zurich 3/45, Switzerland.*

For further information circle 34 on Service Card

35. Semiconductor Photosensors

LANCASHIRE DYNAMO have introduced a range of precision photoheads for switching and counting. Known as the Series MSH.1, this range includes an extensive variety of optical, electrical and mechanical accessories.

A particular feature of this series is that over 40,000 different combinations of light transmitter-photosensor are available to meet individual requirements. The photosensor head can be fitted with alternative cadmium sulphide, cadmium selenide and germanium phototransistor elements, with optical fitments to permit in-line or angled viewing. Similar methods have been employed in the design of the light transmitter units which can be fitted with alternative lamp sizes.

The subminiature assemblies range in diameter from 0·5 in. (1·3 cm) to 1·125 in. (2·9 cm) and the operating distances of the equipment vary from 0·1 in. (0·25 cm) to 40 ft (12 metres).

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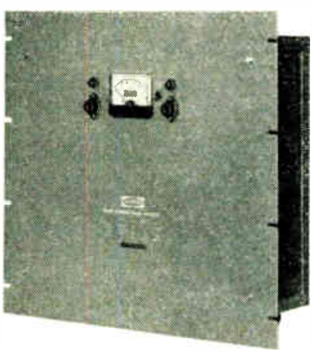

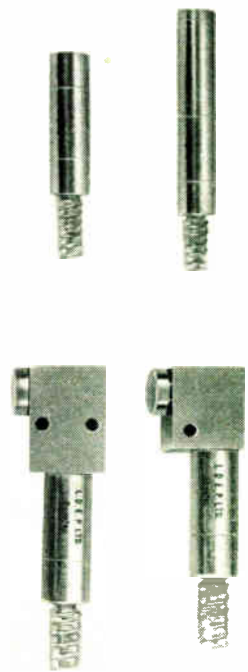

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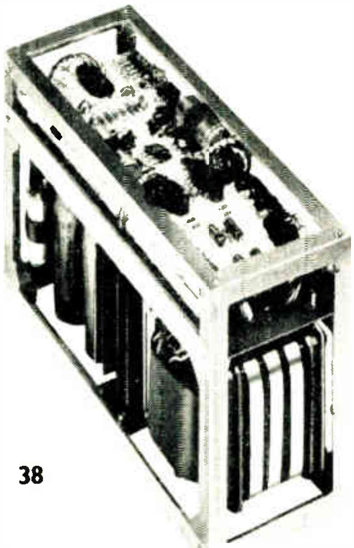

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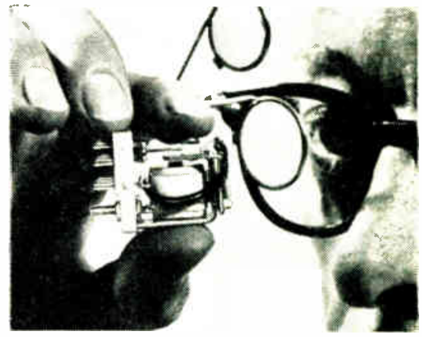

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depending upon the combination of units used.

To complement the range, a number of mounting arrangements are available including cradle, bulkhead, and ball and socket fixings.

Complete equipments incorporating electromagnetic counters utilize semiconductor switching circuits. Reliable counting rates of up to 2,400 per minute are provided.

Alternative models with electromechanical relays are available for control purposes. When used to feed electronic counting and control circuits the photosensor unit operates with pulse repetition frequencies of up to 240,000 counts per min.—*Lancashire Dynamo Electronic Products Ltd., Rugeley, Staffs.*

For further information circle 35 on Service Card

36. Signal Lamp Fitting

THE SIGNAL LAMP fitting type 2214, which has been designed for mounting on equipment panels, has been added to their range of products by Londex.

This unit is of metal and ceramic construction with a choice of coloured bulb lens. The lens colours include red, green and amber; frosted and clear lens are also available. The fitting can be supplied fitted with an M.B.C. neon bulb for operation at either 110 to 120 V or 200 to 240 V a.c. or d.c., or an M.B.C. filament bulb for operation at 6, 12 or 24 V d.c. The overall length of the unit is approximately 2 in. and the overall diameter is $\frac{33}{64}$ in. External connections to the fitting are made to solder tags.—*Londex Ltd., Anerley Works,* 207 *Anerley Road, London, S.E.*20.

For further information circle 36 on Service Card

37. Solder Dispenser

MULTICORE SOLDERS have introduced a solder dispenser, which is claimed to be the first new method of packaging solder for 20 years.

The contents of the new dispenser are 16 ft of 18 s.w.g. Ersin Multicore Savbit Alloy, the solder alloy containing a precise quantity of copper which in controlled tests on manufacturers' production lines, has supported the claim that it makes soldering iron bits last 10 times longer. It is the first time that this particular alloy has been made available to the home constructor and handyman in a 2s. 6d. pack.

The Savbit Solder Dispenser is an extruded aluminium tube, the top being tapered to a delivery hole through which the solder is drawn without tangling, whilst the base is sealed with a polythene cap

In use, the dispenser is hand-held over the joint to be soldered but it can also be used free-standing on the workbench, allowing the user complete freedom of both hands for delicate tinning operations and pre-assemblies. —*Multicore Solders Ltd., Maylands Avenue, Hemel Hempstead, Herts.*

For further information circle 37 on Service Card

38. Power Supply Module

THE RANGE of power supply modules produced by International Electronics has been increased by the addition of the type DSL3 unit.

This is designed for use as a bench power supply or for inclusion in complete equipments. The output voltage can be set by the user within the range 6 to 24 V and the maximum output current is 2 A.

The module measures $4\frac{1}{4}$ in. × $6\frac{3}{4}$ in. × $11\frac{5}{8}$ in; four units can be mounted side by side on a 7 in. × 19 in. panel. — *International Electronics Limited,* 132-135 *Sloane Street, London, S.W.*1.

For further information circle 38 on Service Card

39. A.C. 4-Pole Relay

AN A.C. RELAY designated the KH-AC series, unusually small and compact for its rating and multi-pole contact arrangement is announced by Potter & Brumfield Division of American Machine & Foundry Company. Measuring only $1\frac{9}{32}$ in. × $\frac{55}{64}$ in.

× 1 3/16 in. deep, this relay has an expected mechanical life of 50 million operations. Contacts are rated 3 A at 115 V a.c. or 30 V d.c., resistive. Contact arrangements of 4 Form C (4 p.d.t.) or 2 Form Z (2 p.d.t.-d.b.) are available. Coil operating voltages range from 6 to 115 V a.c. The relay operates on as little as 0·550 VA at 25 °C. Ambient temperature range is from −45 °C to +70 °C with nominal coil voltage.—*AMF International, 261 Madison Avenue, New York 16, New York, U.S.A.*

For further information circle 39 on Service Card

40. Flow-Rate Indicator

DUKES & BRIGGS have developed a flow-rate indicator for fluids. This is known as the 'Telerator'.

In operation, the sensing unit of the indicator is connected into the pipe along which the fluid to be monitored is flowing. By means of a rotating magnet in the sensing unit an electrical output is generated depending upon the state and the rate of flow of the fluid. This output is measured by a milliammeter and is an indication of the fluid flow. By calibrating the unit under one condition of operation it can be used as a direct reading flowmeter.

The 'Telerator' is self-generating, no external source of electrical power is required. It is suitable for use with fluid flow rates up to 20 g.p.m. in 0·75-in. B.S.P. pipes and 45 g.p.m. in 1-in. B.S.P. pipes.—*Dukes & Briggs Engineering Co. Ltd., Approach Road, Trafford Park, Manchester.*

For further information circle 40 on Service Card

41. Deaf-Aid Telephone

A HANDSET designed for telephone users who suffer from defective hearing has been developed by A.E.I. for use with any telephone system employing A.E.I. Centenary Neophone telephone instruments.

The deaf-aid handset embodies a transistorized printed-wiring amplifier fitted in the earpiece. An inconspicuous volume control, fitted to the amplifier, projects through a small slot in the case of the handset so that it can be conveniently adjusted by either hand. The minimum setting of the volume control gives a level of reception equal to that of a standard instrument, and at the maximum position a substantially uniform gain of 20 decibels is achieved over the frequency range 300–3,000 c/s.

The single-stage amplifier derives its supply voltage from the line so that the deaf-aid handset can be incorporated in an existing Centenary Neophone unit simply by connecting its cord.—*Associated Electrical Industries Ltd., Telecommunications Division, Woolwich, London, S.E.18.*

For further information circle 41 on Service Card

42. Pulse Analyser

THE DYNATRON Pulse Analyser Type N.102B utilizes a 9-speed gear box. It is a self-powered 9-speed single channel pulse analyser employing a synchronous motor and associated gear train enabling potentials in the range of 5 to 100 V to be scanned over 9 selected time periods, varying from 11¼ min to 24 hr thus enabling analysis to be carried out non-stop without the equipment having to be watched over.

Finger-tip gear selection is a feature of the N.102B with manual or automatic switching. Its resolution time is less than 1 μsec which allows it to handle very short pulses in quick succession without error.

The analyser is therefore particularly useful for use with scintillation counters.—*Dynatron Radio Ltd., Maidenhead, Berks.*

For further information circle 42 on Service Card

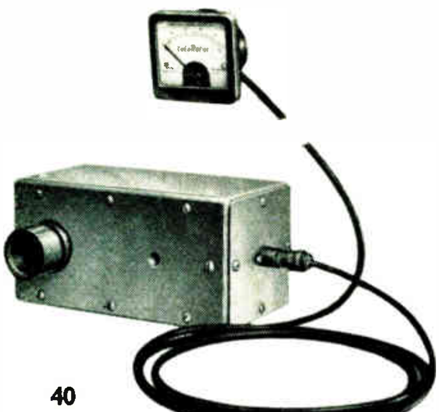
43. General-Purpose Trigger Tube

MULLARD HAVE ANNOUNCED a general-purpose trigger tube, type number Z806W, intended for use in timers, relay control circuits and many similar industrial applications.

The Z806W has many advantages over the already established Z803U general-purpose trigger tube. Perhaps the most important is its ability to operate directly from the positive peak voltage of any mains supply between 200 V and 250 V—a variation of ±15% over this range is permissible.

In addition the trigger ignition voltage characteristic has been improved and the long term stability is better than 1·5 V. Trigger ignition voltage spread is only +1 V or −2 V about the nominal of 120 V, so permitting the use of a single 150 V reference source even in timers of high accuracy.

If the tube is used directly to control a switching operation and not in conjunction with a relay its fast recovery



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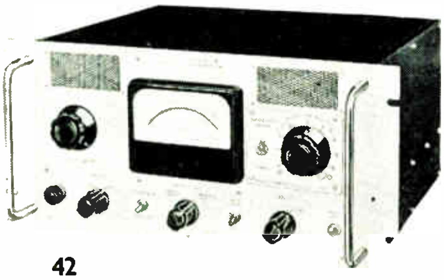

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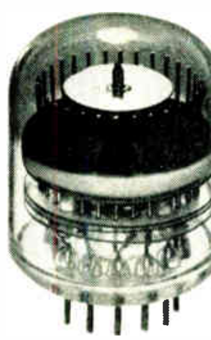

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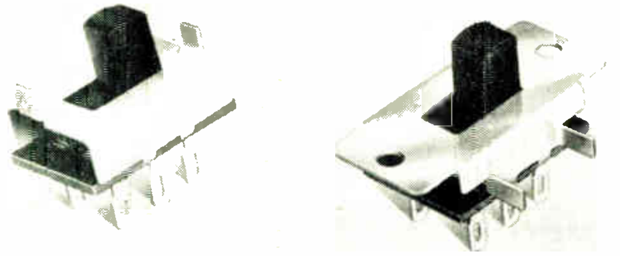

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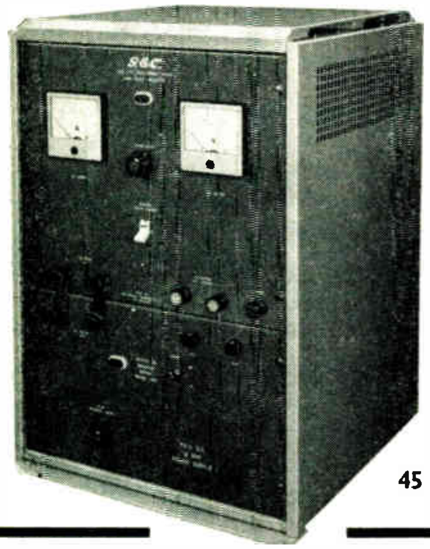

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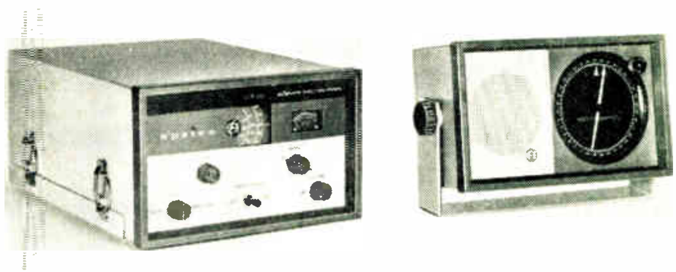

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characteristic makes possible a control circuit which has very little backlash. (The trigger recovery characteristic for the Z806W is four times better than that of the Z803U).—*Mullard Ltd., Mullard House, Torrington Place, London, W.C.2.*

For further information circle 43 on Service Card

44. Slide Switches

RECENTLY INCORPORATED with the range of components produced by Carr Fastener are two slide switches.

The switches are identical in specification but differ slightly in their mounting facilities. Both switches are of the d.p.d.t. type, and can be used for wave-change, instrument, or any relatively low-voltage switching application.

Rated at 1 A, 250 V a.c. with a proof voltage of 1·5 kV a.c. and a contact resistance of approximately 5 mΩ, the switches are fully tested for a minimum of 25,000 unloaded and 10,000 loaded operations.

Constructionally, the switches differ only in the passivated cadmium finished steel shell; switch Part No. 81/812 has vertical fixing lugs whereas switch Part No. 81/811 has two 0·125-in. dia. holes at 1·125-in. centres and alternative side-fixing lugs. The moulded black slider, incorporating an original resilient pad design ensures constant pressure between the internal phosphor bronze bridging contact and the silver-plated solder slot terminals.—*Carr Fastener Co. Ltd., Stapleford, Nottingham.*

For further information circle 44 on Service Card

45. Power Inverter/Frequency Changer

G.E.C. HAVE ANNOUNCED a frequency changer for providing a 1 kVA 115 V 400 c/s stabilized sinusoidal supply from 240 V 50 c/s mains, using silicon controlled rectifiers. The equipment is also available without the input power pack, as an inverter for use with a 100 V d.c. supply.

The frequency stability is ±1% and is independent of load, which may have any power factor between 0·5 lagging and 0·8 leading. The equipment may be operated at any load up to its full rating.

The inverter provides an output which has a very low harmonic component; under the worst load conditions its total content never exceeds 7%.—*The General Electric Co. Ltd., Applied Electronics Laboratories, Stanmore, Middlesex.*

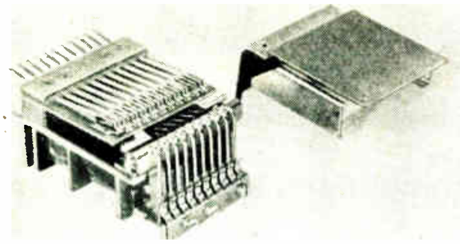
For further information circle 45 on Service Card

46. Automatic Marine Direction Finder

APELCO of the U.S.A. have designed a low-cost automatic marine direction finder known as the model DFR-200. This unit offers a positive, completely automatic means for obtaining accurate bearings using radio signals from ships or land-based stations. The DFR-200 receiver covers 3 bands: 190-420 kc/s; 500-1,150 kc/s; 1,150-2,825 kc/s. It is housed in 2 compact separate units, the receiver-control unit and the radio compass indicator-speaker unit which are readily accommodated in boats with limited space.

Other features of the DFR-200 include: receiver-sensitivity better than 6 μV for 6 dB (signal+noise)/noise; absolute compass sensitivity of 25 μV per metre; 3·5 W audio power output; power supply, 12 and 32 V d.c., 115 V a.c.

Operation is simple and involves no technical or special navigational know-



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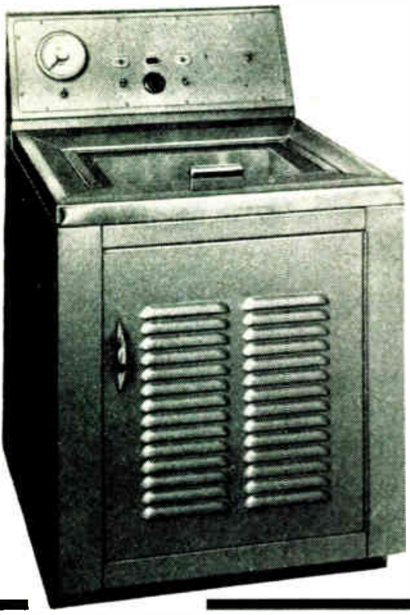

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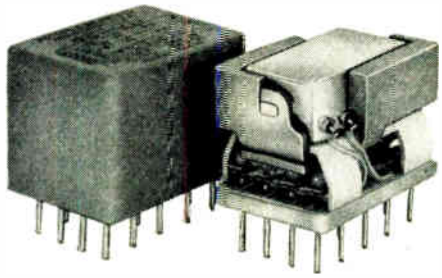

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ledge. The equipment is fully treated for operation in environmental extremes. — *Ad. Auriema, Auriema-Europe, S.A., 172a Rue Brogniez, Brussels 7, Belgium.*

For further information circle 46 on Service Card

47. Counting Relay from STC

A 10-ARMATURE counting relay of unique construction is now available from Standard Telephones and Cables Limited.

Upon receipt of successive impulses this relay 'steps' from one contact to the next, automatically releasing the previously-made contact. There are 10 separate armatures and their associated contacts.

This relay can be used in digital counting in industry; the storage of test data; the recording of specific operations; the 'packaging' of exact quantities for storage and forwarding, and for the comparison of input and output quantities in manufacturing processes.

Advantages of the relay include: simplicity of design; reliability; rapid, vibration-free and silent operation; and low-power consumption.

Its operation depends upon residual magnetism in the armatures and an arrangement of springs: as each armature is energized it closes its own contacts, at the same time releasing the previously-made contact and also operating a 'preparatory' spring for the next contact.

Tests have shown that the residual magnetism of the core is strong enough to hold the complete load of all actuated armatures for several months. There is a 'release' winding on the relay which neutralizes the residual magnetism and restores all contacts to normal.

The relay measures 95 mm by 54 mm by 40 mm (3·75 in. by 2·13 in. by 1·58 in.) overall, including contacts.— *Electro-Mechanical Products Division, Standard Telephones and Cables Ltd., Edinburgh Way, Harlow, Essex.*

For further information circle 47 on Service Card

48. Welding-Cycle Timer

A RE-DESIGNED version of their Series RCW.6 timer is announced by Lancashire Dynamo.

This latest version incorporates printed circuits and can be supplied in a case or in flush-mounted open type construction for building into the user's own equipment.

Designed primarily to provide simple and economical control of weld time duration from 0·1 to 10 sec on spot welding machines, the unit has also found many other applications.— *Lancashire Dynamo Electronic Products, Rugeley, Staffs.*

For further information circle 48 on Service Card

49. Ultrasonic Cleaning Unit

THE LATEST ADDITION to their range of ultrasonic cleaning systems by Savage is the 'Sonic Energy Cleaner'.

This is a self-contained console unit in which are mounted the cleaning tank and generator with the controls located on a sloping panel on top of the console. Made of stainless steel, the tank measures 14 in. × 9 in. with a working depth of $8\frac{1}{2}$ in. and a capacity of $3\frac{1}{2}$ gallons. Eight magnetostrictive transducers are used in the tank driven by the generator which has a rated output power of 800 W average.

In addition to the cleaner a range of rinse, drying, filter and re-heat units are, or will shortly be, available.— *W. Bryan Savage Ltd., Westmorland Road, London, N.W.9.*

For further information circle 49 on Service Card

50. Microminiature Latching Relay

A MICROMINIATURE 4-pole latching relay type TL with hermetically sealed coils is now being marketed by Potter & Brumfield Division of American Machine & Foundry Company.

Designed for environments encountered in missile and other critical applications, its coils, encapsulated and sealed hermetically in a separate metal enclosure within the case of the relay, cannot contaminate the contact structure by outgassing.

Two Alnico magnets linked by a magnetic yoke provide positive latching action. The TL passes 100 *g* shocks with no contact opening. Vibration resistance is in excess of 30 *g*, 55 to 2,000 c/s. Contact rating is up to 3 A at 28 V d.c. resistive.

Available in two-coil construction with a pull-in of 250 mW the TL can be used for alternate pulsing, or may also function as a differential relay. For even greater sensitivity a single coil relay can be furnished with a pull-in of 125 mW. The snap action of the TL produces transfer times of approximately 0·5 msec.

The TL series meets or exceeds all applicable sections of the U.S. specifications MIL-R-5757D and PDR-187. —*AMF International, 261 Madison Avenue, New York 16, New York, U.S.A.*

For further information circle 50 on Service Card

RADIATION DETECTOR TUBES

By F. C. LOVELESS*
and R. D. PHILLIPS

This article describes radiation detector tubes used in Scout I, the International Satellite, which is now in orbit and is being used for measurements of various kinds of radiation several hundred miles above the earth. Some of the tubes employed have industrial applications.

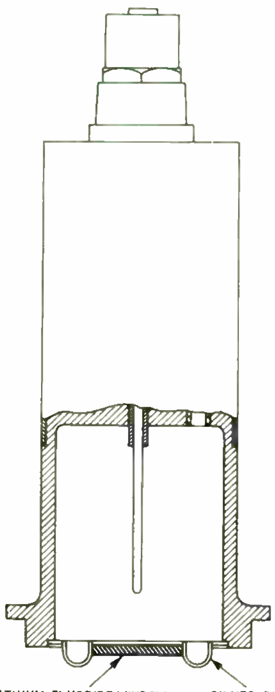


Fig. 1. Ultra-violet detector

THE International Satellite Scout I was launched by the U.S. National Aeronautics and Space Administration (NASA) as part of a co-operative programme of the U.S. and British Governments. The apparatus carried is of British design and manufacture and is intended to carry out measurements of electron density and temperature, ion mass composition and temperature, solar Lyman-alpha emission in the ultra-violet band, solar X-ray emission in the 3–12Å band, and the energy spectrum of heavy primary cosmic rays. The satellite in orbit has an altitude of 200–600 miles and is tracked by the NASA Minitrack stations, one of which is operated by D.S.I.R. at Datchet. The results of the measurements are transmitted to ground by telemetry equipment carried by the satellite.

Three of the radiation detectors were specially made for the work by 20th Century Electronics, and involved special problems. They all had to be as sensitive as possible and yet to be adapted to associated electronic apparatus having a performance limited by weight, space and temperature. Furthermore, they had to withstand severe shock and vibration during the launching of the satellite.

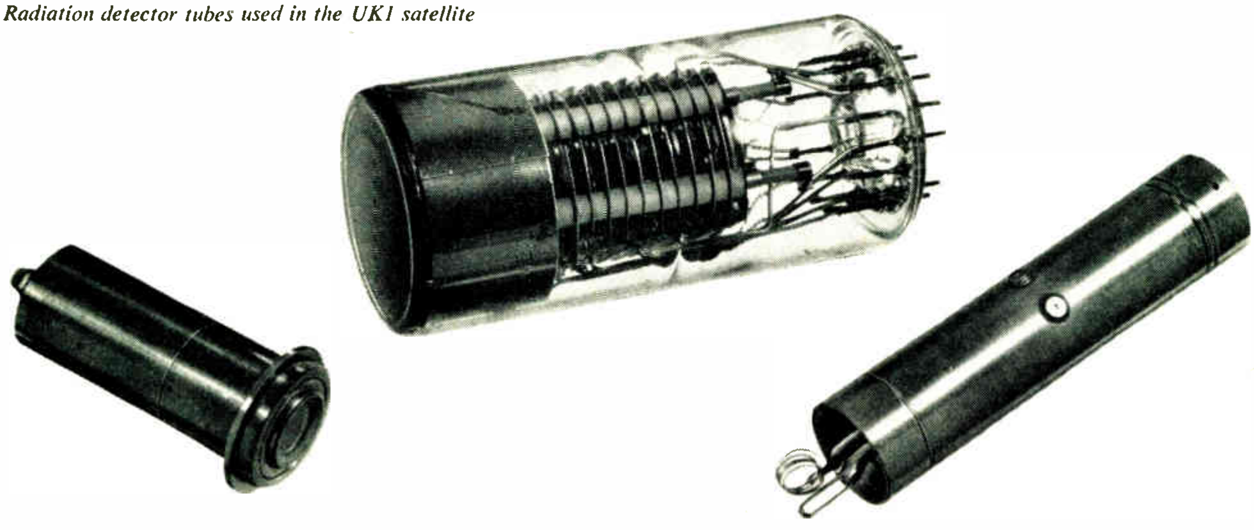
The detector tubes comprise ultra-violet detectors (two), X-ray proportional counters (four) and a photomultiplier.

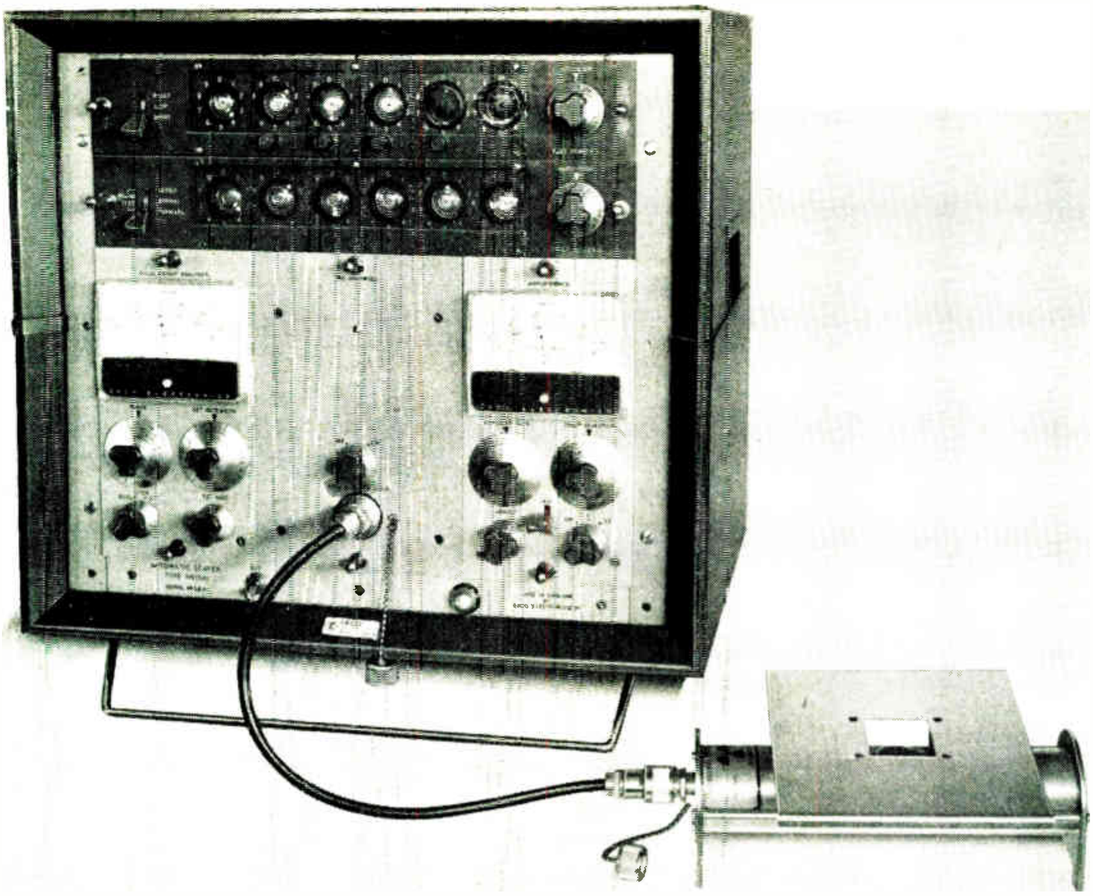
The measurements being carried out in the UK1 are concerned with low-energy radiations associated with solar activity. These radiations although of high intensity in space, have insufficient energy to penetrate the earth's atmosphere. The environment in space contains radiation of many different types and intensities and in measuring a specific radiation effective discrimination between radiations must be maintained.

The solution to this problem is achieved in the detector design. The detector is designed to be sensitive over a narrow spectral range and to be relatively insensitive over the other spectral regions. This narrow spectral band is achieved by a careful choice and

* 20th Century Electronics Ltd.

Radiation detector tubes used in the UK1 satellite





X-ray fluorescence analyser, using a proportional counter. (Photograph by courtesy of Ekco Electronics Ltd.)

combination of the materials of construction of the detector and this approach to design is well illustrated in the case of of the ultra-violet detector type UV1.

Ultra-Violet Detector

The ultra-violet detector is an ion chamber with a lithium fluoride window and a nitric oxide gas filling. The window passes ultra-violet radiation down to 1100Å and the gas filling responds efficiently up to about 1350Å, so that the response range extends well around the wavelength of the radiation it is desired to detect, at 1260Å. This is the hydrogen Lyman radiation given off from the surface of the sun.

An ion chamber is an inherently rugged device for it comprises merely a single central electrode in an outer shell

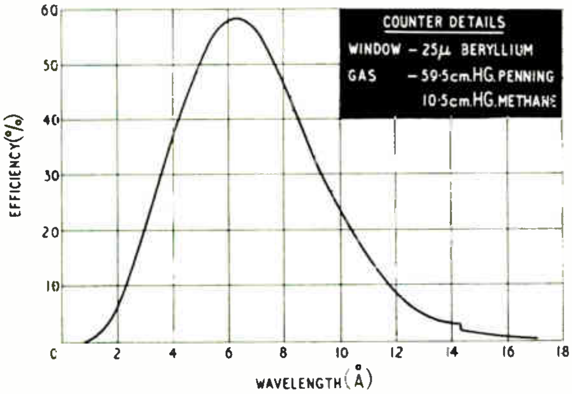


Fig. 2. Spectral response of PX 28K

Electrically, however, it is essential that very high electrode insulation should exist in order that small ion currents can be measured accurately. It is further essential that the tube should be stable and that the ion current should saturate so that the applied polarizing voltage is not critical. Both these require that the nitric oxide filling be very pure and the chamber truly vacuum tight.

Special techniques had to be developed for purifying nitric oxide; impurities amounting to only a few parts per million were permissible. Great attention to the sealing of the lithium fluoride window to the glass body of the chamber was also needed. The window is cleaved from a single crystal of lithium fluoride grown in vacuum and accurately ground along the axis. After cleaning the crystal must be untouched by hand if the transmission properties are not to be affected.

The interesting method of construction of the window can be seen in Fig. 1. To avoid fracture of the lithium fluoride window under the reduced external pressure conditions in space, the window is mounted in a silver ring. This ring is sufficiently flexible to reduce the strain on the window material and so prevent fracture.

Further detectors of this type are being investigated using different combinations of window and gas filling to provide a number of narrow spectral band detectors between 1000Å and 1500Å.

Proportional Counter

The proportional counter for X-rays is also a gas ionization detector and intrinsically rugged in construction. A fine anode wire is suspended inside a cylindrical metal cathode. The X-radiation enters the counter through a beryllium window of 25μ thickness and 2 mm diameter. The gas filling of the counter, neon-methane mixture, was chosen because while it had enough stopping power for the low-energy radiation it was relatively transparent for the high-energy background radiations and no fluorescence radiation is produced in the wavelength region to be measured.

The PX28k proportional counter is used as a spectrometer in the UK1 for the measurement of the solar X-ray spectrum and its spectral response is shown in Fig. 2.

The employment of a proportional counter as a spectrometer is due to the fact that the magnitude of the pulses from the counter bears a direct relationship with the energy of the radiation being measured. If the pulse height is measured it will be found to be proportional to the energy of the exciting radiation and the energy spectrum of the X-ray source can be determined by the measurement of the pulse-height spectrum.

The amplifiers to be used with these tubes have no gain adjustment and the e.h.t. supply is limited. Because of this the tubes all had to have a gas multiplication within 2 dB of a mean value. This was attained by testing the gas multiplication while filling the tubes on the filling pump and making adjustments of less than 1% to the gas pressure.

The ruggedness had to be sufficient to withstand vibration tests which were carried out in the frequency range 20–2000 c/s with r.m.s. accelerations up to 11·5 g. In order to achieve this special attention was paid to the material of the anode and to the details of the fine-wire anode support.

Photomultiplier

The photomultiplier tubes are used to 'look at' Cerenkov radiation from a Perspex sphere. A high cathode sensitivity and low noise are necessary together with high gain at a low overall voltage. These are, however, normal attributes of standard 20th Century tubes and comparatively few modifications had to be made to meet the requirements. The main difficulty lay in achieving sufficient ruggedness, for the tube is a complex structure. The normal construction with the dynodes mounted on ceramic rods is itself a robust one, however, and it only proved necessary to make a simple addition to the evaporation ring structure.

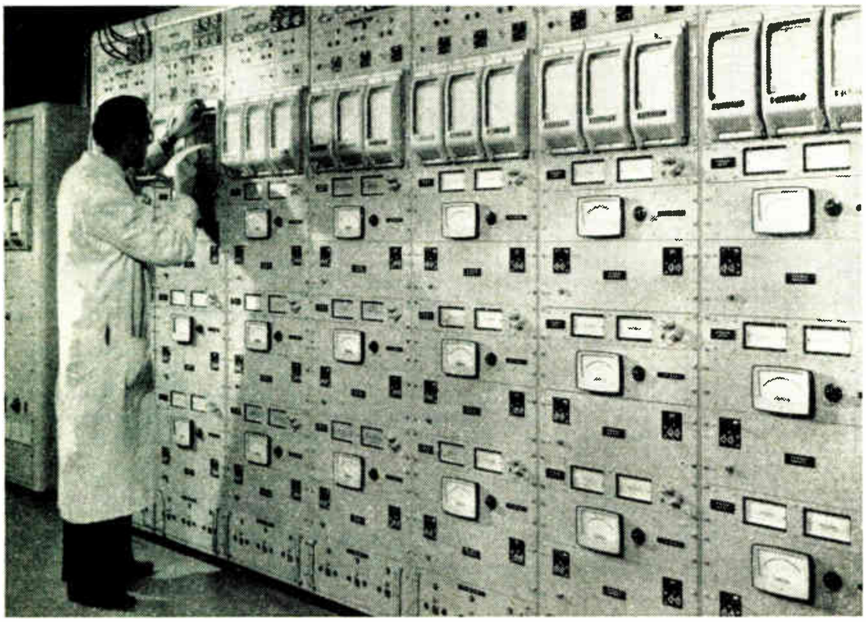
It was found that normal tubes tended to fail when vibrated in the 50–500 c/s range at accelerations over 20 g. The modifications entailed making the cathode screening cylinder as a solid sleeve and mounting the evaporation ring as far as possible independently of it, supported at several points. Double welding at each end of the 'tapes', internal supporting of the cathode screening cylinder by strong springs with resonance frequencies in the kilocycle range, a double layer of silver for the counter layer with multiple spring contacts removed the early failures and resulted in a tube able to withstand vibration up to at least 30 g.

Industrial Uses

The development of these detectors and many others, usually as tools of fundamental research, has led to the incorporation of improved features in the customary detector designs used in medical and industrial applications. In addition new industrial measuring techniques have developed exploiting the unique properties of the new detectors.

For example, X-ray proportional counters are finding industrial application in the technique of X-ray fluorescence analysis because of their energy selective properties. The X-ray fluorescence method relies on the fact that X-rays characteristic of a particular material can be excited by radiation from a radioactive source. The material can be identified by a measurement of the energy of the characteristic X-ray. The method is cheap and the complete instrument, the Ekco fluorescence analyser, is illustrated in one of the photographs. The thickness of coatings on a suitable base material can be measured by exciting the X-ray from the base material and measuring the decrease in intensity of this radiation with the increase in coating thickness. This technique can be adapted to extreme factory conditions and is currently being employed in the production control of the thickness of tin-plating on steel sheets after hot dipping.

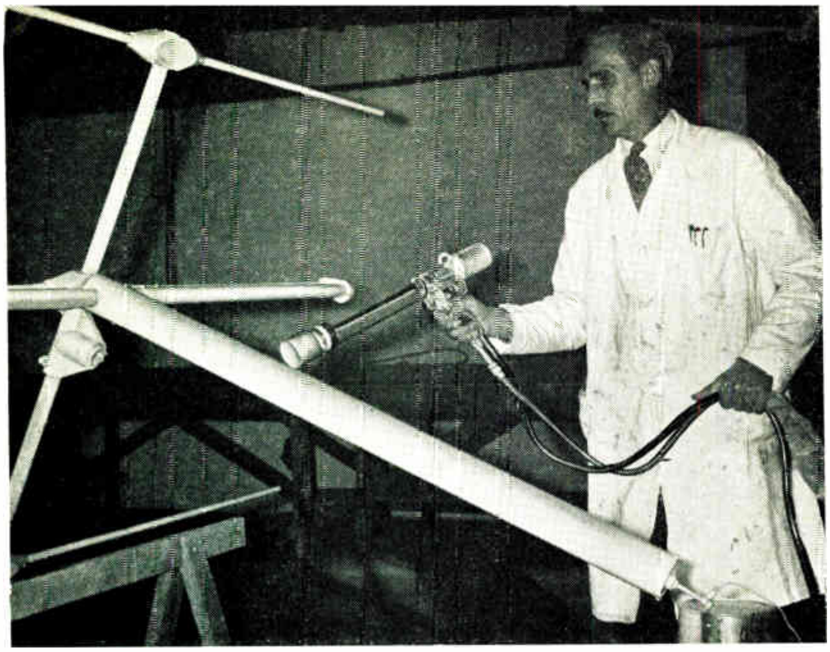
Submerged Telephone Repeater Test Set



This suite of equipment has been designed for the confidence testing of submerged repeaters of the type inserted at intervals in submarine telephone cables and are thus laid at the bottom of the sea. The function of the test set is to monitor repeater gain continuously for several months in the factory prior to accepting a repeater as satisfactory. It was manufactured by Elliott Brothers (London) Limited

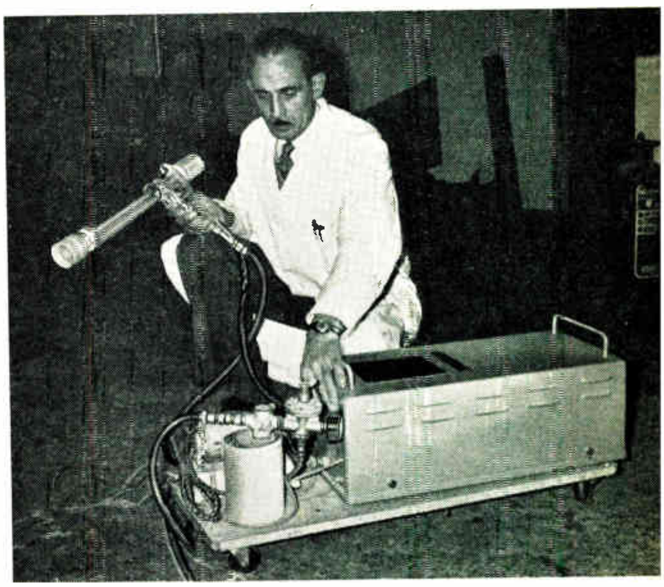
APPLICATIONS ILLUSTRATED

ELECTROSTATIC PAINTSPRAYING



Here a single-gun unit is being used at the Northampton works of Radio Telephone Aerial Systems Ltd. to spray a B.B.C. Band I aerial for the television satellite station at Fort Augustus. The paint in use is a high flash point epoxy resin enamel and the gun is a S.A.M.E.S. Statron unit which will spray tubes of up to 6-in. diameter from one side of the work

WHEN frames, wire mesh, tubular components and similar openwork products are to be painted, the advantages of electrostatic spraying become apparent. Electrostatic paint spraying is now an established technique in which the globules of paint are electrostatically charged as they leave the gun. The charge of the paint globules is of opposite potential to that of the object being sprayed. Therefore the paint is attracted to the object and, because of the 'wrap-around' effect, even tubular products can be covered with paint without moving the gun around the object. The absence of overspray means greater economy in the use of paint and that spraying can be carried out without extensive spraying booths and exhaust systems.



This shows that the space occupied by the complete Statron unit is comparable to that occupied by a conventional compressor spraying equipment

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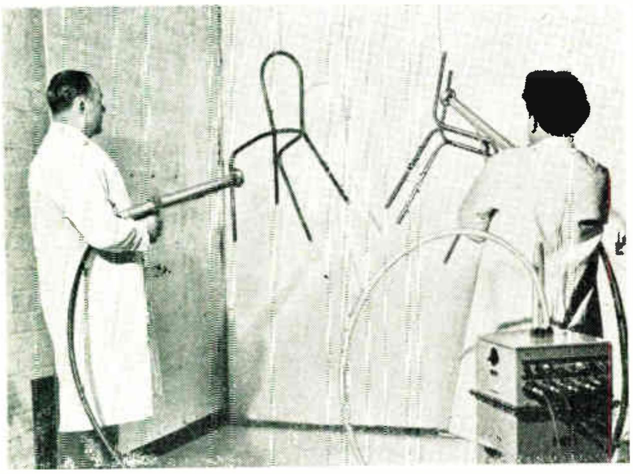

Hursant Developments have produced a multiple-gun hand spraying unit known as the Statispray Mk. III. Here two spray guns are being operated from one unit. The equipment consists basically of a gun and a generator with an output of 140 kV, in which an r.f. generator feeds a cascade voltage multiplier. A safety circuit limits the maximum charging current to 100 μA

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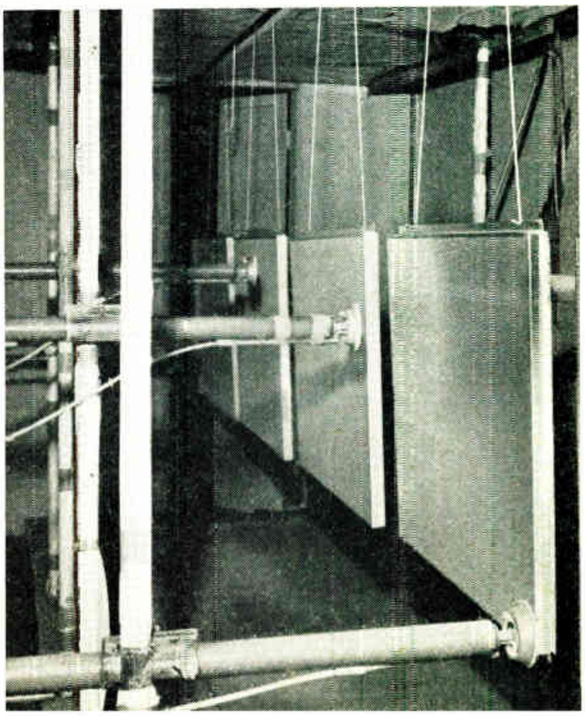
A fixed installation of the Hursant Statispray Mk. III units in action, spraying a series of panels which are being carried past the spray heads on an overhead conveyor



MEMORY AND LEARNING CIRCUITS — part 2

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

This article, which is concluded from page 100 of the November issue, describes a quantitative memory unit called EMMA which has been built as a model of a simple system capable of learning.

We shall next describe a quantitative memory unit which is now being built by the author. This memory unit is the central part of a machine simulating man's ability to examine a visual field in order to discover and remember the positions of objects, which may constitute hazards or goals. The machine has been given the title of EMMA (Eye Movement Memory Apparatus) which though bizarre is concise and so will be used hereafter.

Fig. 8 shows a block diagram of EMMA. The eye consists of a matrix of photosensitive elements, and because of the practical inconvenience of moving the whole eye, movements of it are simulated by means of the mirror system shown diagrammatically in Fig. 9. The position of the mirror, which is inserted in the optical pathway between the eye and the environment, is controlled by means of two conventional position-control servo-mechanisms, the 'Y' system turning the mirror about its horizontal midline, and the 'X' system turning the whole aluminium frame, to which the 'Y' motor and potentiometer are fixed, about a vertical axis. Both systems are critically damped.

The environment, for the purposes of this machine, is composed of a plane sheet of opaque glass from behind which spots of light can be shone to represent objects. A very convenient way of describing position in this environment is by measuring the voltages at the X and Y feedback potentiometers when the eye is looking at the position. This pair of voltages will hereafter be referred to as the co-ordinates of the position.

The search pattern generator produces a pattern of fixations separated by random jumps. Each fixation is maintained for an adjustable time of about $\frac{1}{3}$ second. This behaviour is intended to mimic random saccaddic movements measured in humans engaged in search problems[6,7], although this is certainly not the only kind of pattern used. Ford, White, and Lichtenstein[8] showed that this initial random search changed with experience, under the particular circumstances of their experiments, to a circular search, although the saccaddic nature remained. This change of search pattern, and also changes to other patterns (for example a line by line scan as in a television camera) must almost certainly be governed by another learning process, choosing in any particular set of circumstances the kind of search which had proved successful in the past in those circumstances. In EMMA, however, the random search pattern is the only one included.

Referring once more to Fig. 8, we can now follow the whole pattern of events. When an object in the environment comes into the field of view as a result of an appropriate movement of the eye movement simulator, signals from the eye activate the detection and fixation units. The detection unit suppresses the search pattern, and the fixation unit operates the eye-movement simulator until the eye is fixated on the object. The voltages on the feedback potentiometers are then the co-ordinates of the object as previously defined. These co-ordinates are presented at the inputs of the memory elements and of the comparison unit. A signal from the coincidence unit then starts the recall selector presenting the co-ordinates from each memory element in turn to the comparison unit. The purpose of this is to find out whether the object is a 'new' one or one which has already been remembered. If the object is not a 'new' one, then the comparison unit causes the storage selection unit to store the memory in the same element again: if the object is a new one, then its co-ordinates are stored in that memory element which has the smallest strength of memory component, unless every element has a high strength of memory component, when the new memory is rejected instead of an old one being destroyed.

The memory examination unit shown acting on the recall selector consists of a set of push buttons by which the experimenter can make the eye return to the position whose co-ordinates are stored in a particular memory element. This is convenient for experimental purposes, and can also be used to simulate the ability to recall a memory when not acting under the stimulus of the appearance of an object in the environment.

Each memory element consists essentially of three capacitors in which charge can be stored to represent two co-ordinates and a strength of memory component.

* University College, London.

Storage and recall are effected by relays, designated S and R respectively. Fig. 10 shows the circuit diagram (slightly simplified) of the memory element. The upper part relates to the storage of co-ordinate X (the Y circuit is identical) and the lower part to the storage of the strength of memory component.

When the S relay is operated, it is kept closed for a definite time (about $\frac{1}{4}$ sec). The time constants C_xR_x and C_yR_y are made very small compared with the operating time, but the time constant C'_yR_y is large (several seconds). This means that the co-ordinate capacitors charge up to the full voltages applied from the feedback potentiometers, but the strength of memory capacitor receives only an increment of charge to take its voltage towards that of the negative supply. The outputs from the co-ordinate capacitors are taken through cathode followers and inverting amplifiers whose gains are adjusted so that the outputs are exactly equal in magnitude and opposite in sign to the co-ordinates originally fed in. The inversion is convenient both for the comparison unit, where the measurement of the difference between two voltages becomes the measurement of their sum, and also for the servo systems, where a demand signal of $-V$ volts is necessary to move the system to the position whose co-ordinate is $+V$ volts.

The charge representing the strength of memory produces two output signals, as shown in Fig. 10. One output goes to the storage selection unit so that as the strength of memory increases the destruction of the memory to make way for new information becomes progressively more difficult and ultimately impossible. This is a realization of a first threshold. The second threshold is produced by the other output, which goes to the recall selector, making manual recall impossible unless the strength of memory is sufficiently large.

Nine memory elements are provided altogether in EMMA, a total decided upon not primarily for the sake of physiological realism (although it does seem to be of at least the right order of magnitude) but for reasons of mechanical convenience.

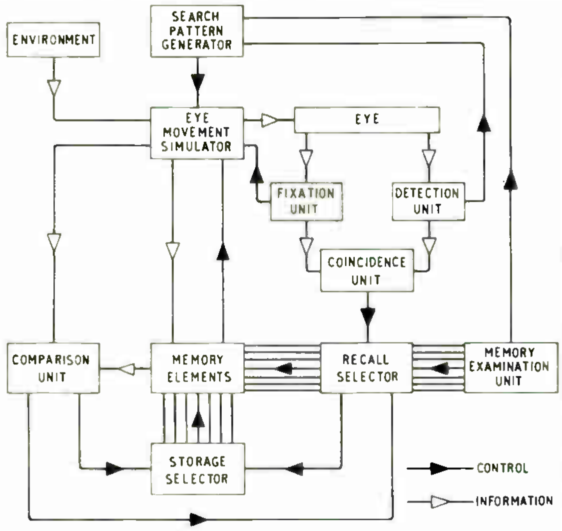


Fig. 8. Block diagram of EMMA

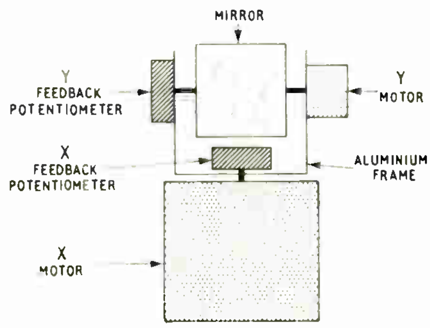


Fig. 9. Eye movement simulator

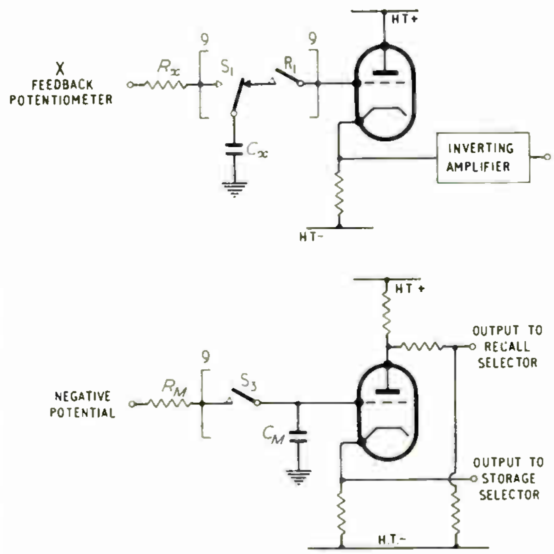


Fig. 10. Memory element in EMMA

Possible Neurological Parallels

We will conclude this discussion of learning and memory systems by considering briefly how these different types of learning circuit might be realized in neurological terms.

Association and classification circuits can be considered together, since, as suggested earlier, an association circuit can be regarded as simply a special case of a classification circuit.

One theory to account for the operation of classification learning circuits is that advocated by Taylor[9], and suggests that learning is due to changes in interneuronal transmission characteristics. The suggested mechanism is that trains of nerve impulses produced by some particular input pattern, which may be visual or otherwise, have a choice of a number of different possible paths they can follow on their way to producing one of a number of possible responses. In an untrained animal the particular choices made are random, but during the training process the response is specified and the paths taken by the nerve impulses have to be such as to lead to the correct response. The hypothesis is that with an increase in the number of impulses which have traversed a path, the transmission strength of that path is increased from zero towards a maximum, so that the training procedure, by directing the flow of impulses, creates preferential paths for the particular input pattern leading to the particular response. Thus if the same input pattern is presented on a subsequent occasion, the nerve impulses produced traverse the same paths and so produce the same response. A machine built

memory and learning circuits

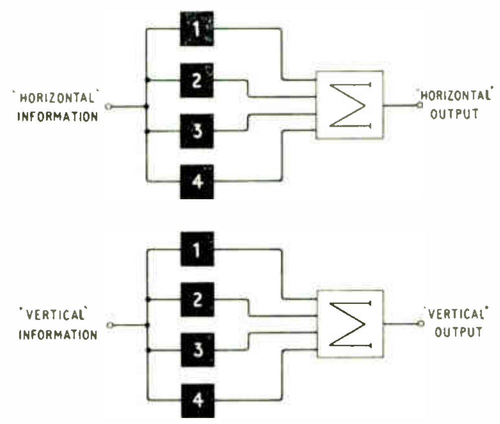


Fig. 11. Postulated position memory element

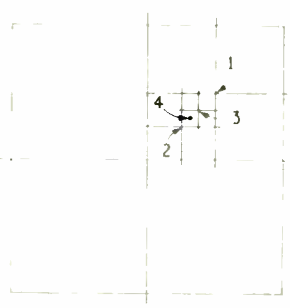


Fig. 12. Build-up of position in successive elements

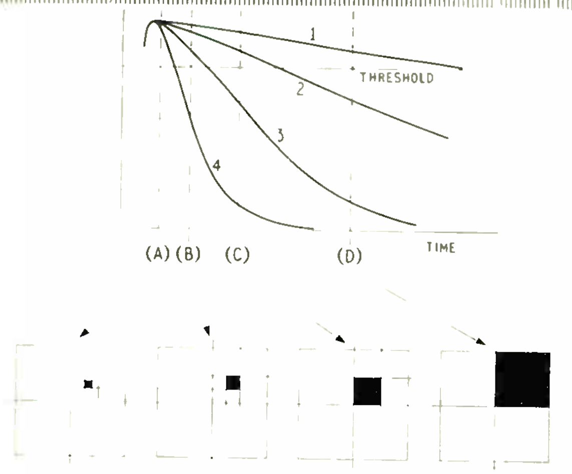


Fig. 13. Forgetting rates and loss of accuracy

by Taylor[10] has demonstrated that this postulated property of the nerve cell (or more strictly, of the synapse which is the interneuronal junction) is a sufficient condition for the learning of simple shapes, provided the neurones are distributed in certain characteristic ways.

Uttley has advanced the hypothesis that the nervous system contains a classification system, and indeed it was on the basis of this hypothesis that he constructed his machine[5]. One consequence of this hypothesis would be the necessity of an analogue to digital conversion network, and he has found physiological evidence[11] which suggests that such a conversion might in fact take place in the cochlear nucleus of the cat.

Neither of these two hypotheses conflicts with known anatomical or physiological evidence, and each has been shown, by means of a model, to be a possible basis for association and classification learning circuits.

With position-learning circuits however the situation is more difficult, since information must be stored to represent not only the strength of memory, but also the quantitative aspect of the memory. Turning again to EMMA's memory element, we find a provision for three quite separate but synchronized storage elements. One of these, the strength of memory element, is not unlike the memory elements of Uttley and Taylor: the charge is increased with each incoming memory, and continuously decays exponentially towards zero. This kind of effect, of a gradual growth from zero combined with a tendency to return to zero, could well be produced in the nervous system, perhaps by chemical means. The quantitative part of the memory, however, has quite different properties. Here the amount of charge contained in the capacitor is significant in itself beyond merely determining a state relative to a threshold. Moreover, the charge does not build up gradually, but must reach its 'correct' value at once: the position of a single object on an otherwise blank field can be accurately recalled after a single brief presentation. A single neural element which will behave in this manner is very hard to envisage. Moreover the existence of a separate element providing a strength of memory component seems very improbable. The alternative appears to be that the only stored quantity should be that representing the strength of memory, the quantitative information being specified in some way by the connections.

One possible way of producing a memory unit with these properties would be to imagine the sensory field divided up by a grid, and to have a separate memory element provided for each square of the grid. This would really be the same as Uttley's classification principle: a memory element is provided for every possible position. This hypothesis must, I think, be rejected, partly on the grounds that it would predict a virtually unlimited capacity for memories, which does not seem to be consistent with experience, but also because it would predict a constant accuracy, the sole criterion being a threshold determining whether an object in a particular position is remembered or not.

An alternative hypothesis, which avoids these difficulties, is to suppose that each memory element consists of a number of neural elements, as shown diagrammatically in Fig. 11, each one contributing to a different extent to the final quantitative result. Thinking again of a position in a visual field, we can suppose that each neural element makes a binary decision, so that the successive stages of arriving at a position may be as shown in Fig. 12, where the numbers show the positions which would be indicated by the corresponding pairs of elements in Fig. 11 in the absence of the succeeding elements. Clearly the accuracy and discrimination can be made as high as we like by taking sufficient stages. Moreover, if we further suppose that the rate of forgetting is not constant for all elements, but is greater for elements concerned with detail than for the earlier ones in the chain, then we have an explanation for loss of accuracy preceding total loss of memory. This is illustrated in Fig. 13 which shows exponential decay curves with different time constants associated with the four pairs of elements of Fig. 11, as the 'area of uncertainty' corresponding to recall as the quantity stored in each successive pair of elements falls below the threshold. The same effect could be obtained if the elements had the same time constant but different thresholds.

So far we have considered only temporary memory units. Temporary changes in the sensitivities of nerve cells can be produced by chemical means. A permanent change might come about by growth of the synaptic region, and this growth might in fact be stimulated by the chemical changes which represent the temporary memory. It would however seem to be undesirable that a permanent memory, however faint, should be produced immediately by a temporary one, for many memories concern events whose importance is intrinsically temporary. For example, the relative positions of the dining car and a particular seat in a train is of importance for perhaps half an hour while a passenger is in one place and his possessions are in the other, but thereafter it becomes insignificant, and a few weeks or even days later, especially if he has undertaken other railway journeys in the meanwhile, he will be unable to recall this information. For this reason the third threshold referred to earlier is now postulated as the level to which the temporary strength of memory must be increased before a permanent effect begins to appear.

Conclusion

We are led by a consideration of the necessary properties of memory systems to adopt as a working hypothesis the theory that in all memory circuits the strength of memory is the only component of memory to be stored, the qualitative or quantitative components being specified by the connections. As a consequence of this, we are led to suggest further that a quantitative memory element consists of a group of neural elements with different forgetting rates.

This theory answers some questions but raises others: in particular the idea of a succession of binary decisions is not altogether easy to accept. There are some nerve cells which might operate as two-state devices, producing sequences of nerve impulses at one of two fairly clearly defined frequencies, but most produce output impulses at a continuously variable frequency, dependent on the strength of stimulation. This continuous output could, however, become effectively two-state by acting on a cell possessing a frequency threshold.

At present, of course, these theories are no more than speculation, but in a field in which so much remains to be explained, even speculation can be of value in suggesting further models and experiments, the results of which can then be used to modify the original theory.

Acknowledgments

I have received considerable help by way of suggestions, comments, and criticisms from members of both the medical and the engineering staffs of University College, London. My thanks are due to them all, and in particular to Dr. W. K. Taylor and Professor J. Z. Young for many stimulating discussions on the problems of learning. The financial support of the Nuffield Foundation is also gratefully acknowledged.

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PIEZO-MAGNETIC ANALOGUE MULTIPLIER

Addition and subtraction, differentiation and integration may be performed by simple circuits in an electronic system, but the operations of multiplication and division are much more difficult to realize.

In the October issue of the *NRDC Bulletin* a new type of piezo-magnetic analogue multiplier is described*.

The multiplier comprises a bender-type piezo-electric crystal, clamped at one end and carrying two soft iron armatures or strips at the other end, one each side of the crystal. Opposite each of the armatures, and separated from it by an air gap, is a laminated silicon iron C-core. The two C-cores carry a total of four coils, two on each C-core.

Let the electrical input quantities to be multiplied be represented by currents X and Y. On one C-core the coils are connected in the same sense, and the magnetic field produced when current is passed through the coils is proportional to $X+Y$. The resulting magnetic force exerted on the armature is proportional to $(X+Y)^2$. If the coils on the other core are connected in opposition, and the currents are again represented by X and Y, the magnetic field is proportional to $X-Y$ and the resulting magnetic force exerted is proportional to $(X-Y)^2$. The two forces acting on the crystal are in opposition and therefore the net force is $(X+Y)^2-(X-Y)^2=4XY$. As the voltage output from the crystal is proportional to the force applied to it, the output is proportional to XY.

The prototype multiplier described was constructed with a Rochelle Salt crystal. The author admits the limitations of Rochelle Salt in this application and suggests that lead zirconate titanate would be better.

The performance of the Rochelle Salt multiplier is:

Peak inputs ± 5 mA
Peak outputs ± 250 mV
Input resistance 200 Ω
Input inductance 70 mH
Resonant frequency 1·5 kc/s
Errors less than ± 1% of full scale
Power consumption 5 mW.

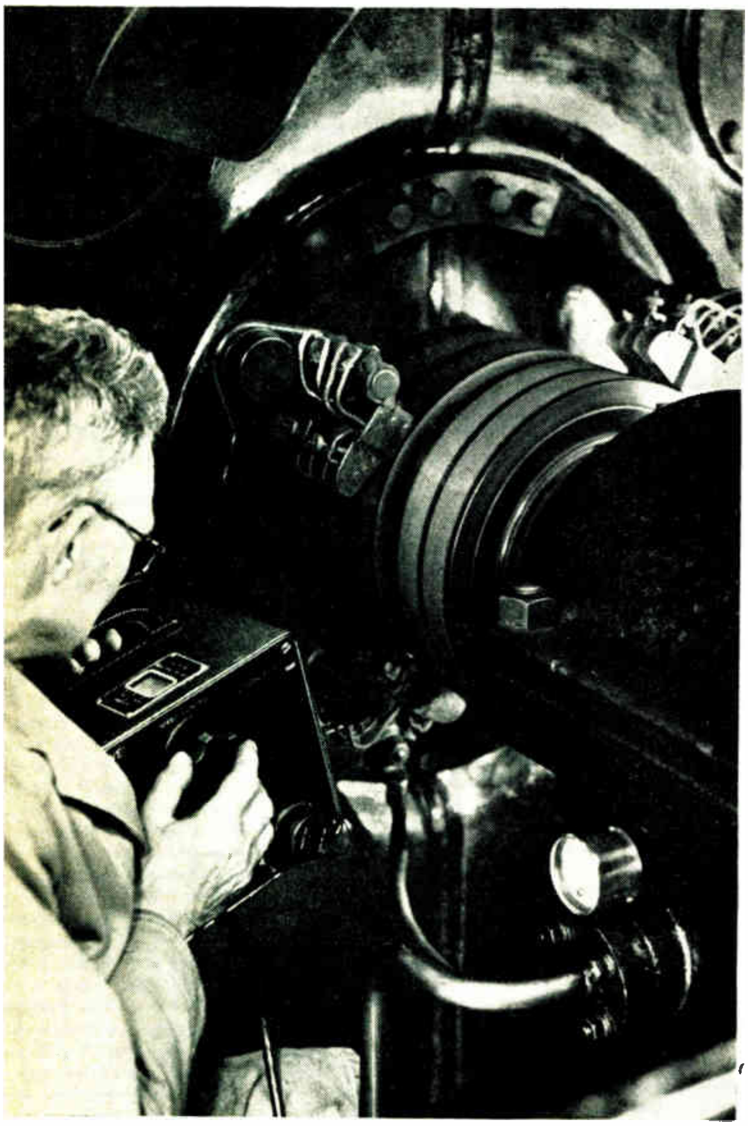
The peak in the output frequency response due to the natural mechanical resonant frequency of the crystal assembly can be removed with an active RC filter and this results in a frequency response flat from 15 c/s to 500 c/s and 1 dB down at 10 c/s and 1 kc/s.

* W. P. L. Wilby, 'The Piezo-Magnetic Analogue Multiplier', *NRDC Bulletin* 21st Oct. 1962, pp. 10–14.

The stroboscope is a well-known device for 'freezing' regular motion. In this article some typical applications are described, together with some special-purpose equipment.

STROBOSCOPES IN INDUSTRY

*By W. G. A. McCORMICK**



Checking a commutator for wear by freezing motion with a Type 1200 Stroboflash

THE true stroboscope provides a valuable means of inspecting the operation of machinery while it is actually in motion. Consider a wheel revolving at, say, 600 rev/min (10 revolutions per second); due to persistence of vision, the spokes appear to blur and individually are not visible as separate entities. This is because the sensation caused by an image on the retina of the eye lasts about $\frac{1}{10}$ of a second or more and the images of the spokes are superimposed on one another resulting in blur.

If the wheel is viewed by the light of a flashing lamp which flashes 10 times per second (10 c/s) the wheel will appear to be stationary—its motion will be 'frozen'. The flashing light, or 'stroboscope' is acting as a visual gate allowing the wheel to be viewed at one particular position of its cycle only. All other positions are shrouded from the observer by the comparative darkness between flashes. Persistence of vision will make the light appear to illuminate the object continuously for all practical purposes, although at fairly low flashing frequencies (about 10 c/s) flickering will just be apparent.

Variation in the flashing frequency of the stroboscope produces other effects. If the flashing rate is reduced to 9 per second (9 c/s) the wheel will appear to revolve slowly at one revolution per second in, say, a clockwise direction. Increasing the rate to 11 c/s results in apparent rotation at the same speed but in the opposite direction.

This stroboscopic effect has been the cause of a number of accidents in factories employing rotating machinery, particularly where early types of fluorescent lighting powered from alternating current mains were used. A fluorescent tube powered from 50- to 60-c/s mains is in fact flashing on and off at double that frequency. It can cause moving machinery—viewed under this light—to appear stationary or to be moving in slow motion in a similar manner to that described above for the true stroboscope. This has sometimes tempted an unwary operator into touching the apparently safe machinery, with possible disastrous results.

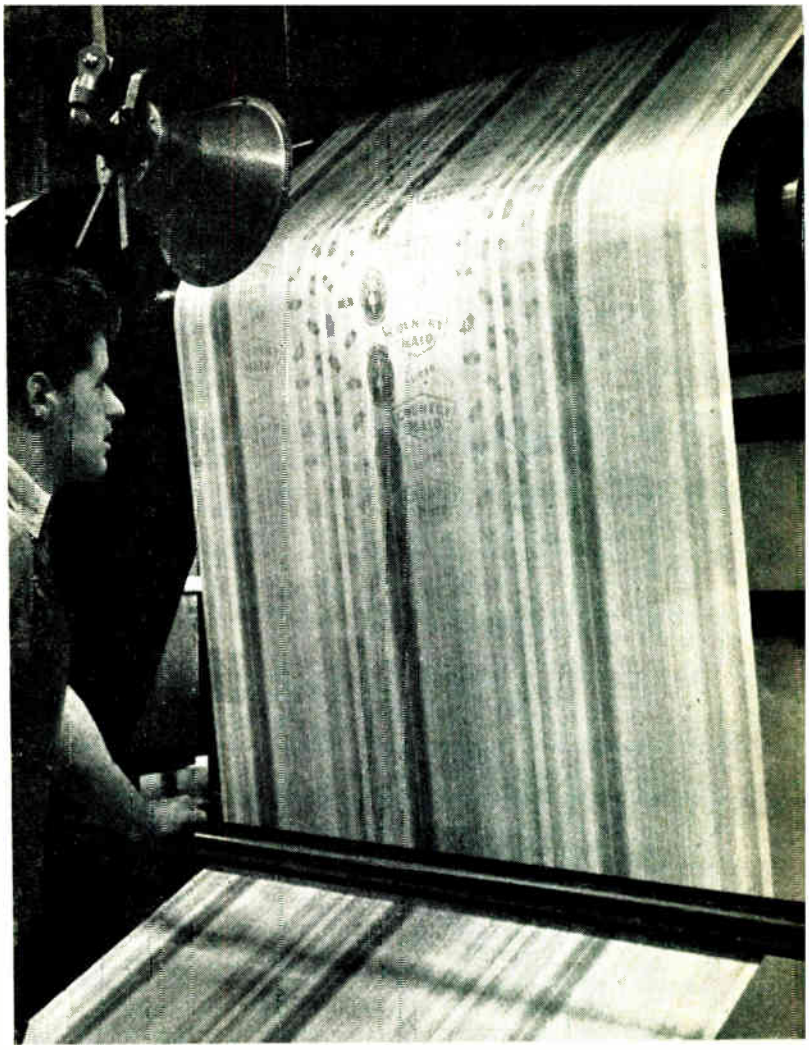
The problem is overcome by mounting the fluorescent tubes in pairs and arranging them so that they are connected to different phases of a three-phase supply. They are thus flashing 120° out of phase with each other and

* Dawe Instruments Ltd.

the stroboscopic effect is lost. Filament-type lamps also nominally suffer from this effect, but owing to the fact that the filament takes a finite time to heat and cool, the output from the lamp is almost constant and the stroboscopic effect is negligible.

A number of stroboscopic instruments are available which employ this 'freezing' effect to advantage. One interesting application is found in the printing industry. In flexographic printing, type made of plastic or rubber is used in conjunction with very freely flowing ink. The pressure between the impression roller and the paper is extremely light, giving what is called 'kiss-impression'. This process is used mainly for printing on waxed paper, such as is used for bread wrappers, because ordinary metal type would cut through the wax like a typewriter cuts through a stencil. This would render the paper useless for wrapping. To obtain a high output, the presses are run at high speeds—up to 700 ft per minute or more—but the setting is critical. Too much pressure will distort the type and even a slight under-pressure will result in thin printing or in no impression at all. The light pressure and special type employed avoid tearing even the thinnest paper and the special inks have quick-drying properties enabling several colours to be printed in rapid succession.

Such high printing speeds coupled with the difficulties in printing directly off the reel necessitate constant and careful inspection. The printed paper is wound on to a take-up roller fitted with a slipping clutch to provide a constant tension as the paper builds up on the roller. Should the clutch slip or stick the paper tension and consequently the stretch will vary, altering the register of one or more colours. At the high operating speeds usual with the flexographic process some hundreds of yards of paper may be ruined before the fault is discovered.



When this photo was taken the paper was running at a speed of 700 ft/min. The stroboscope makes the printing appear stationary

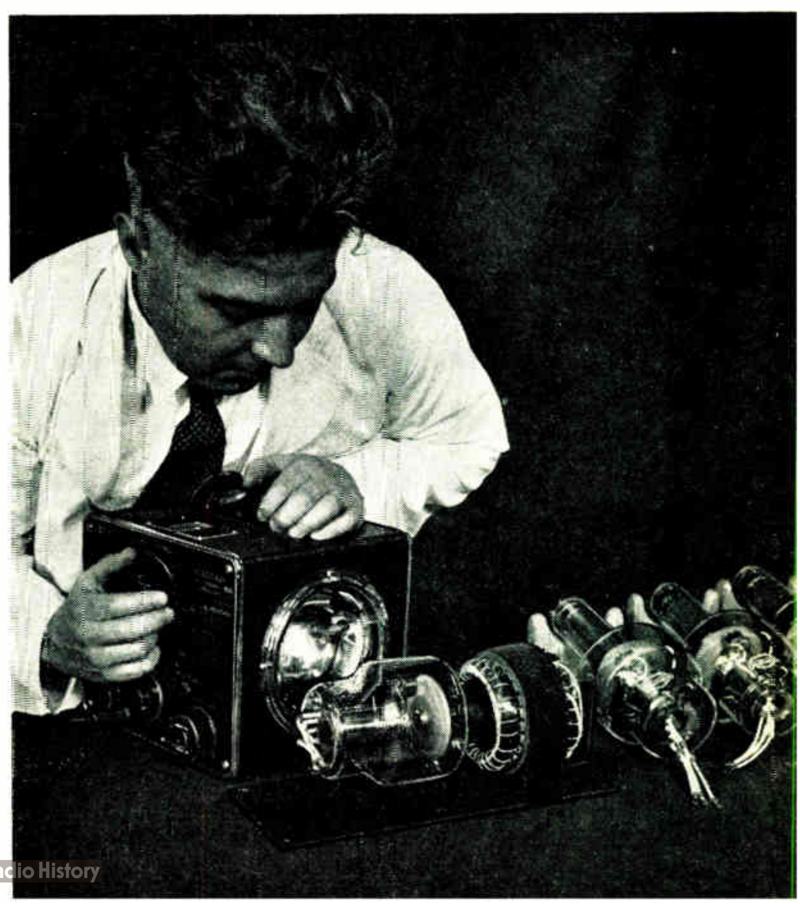
Checking Register in Printing

Visual inspection by the operator greatly restricted the possible speed of printing and the problem of coupling a low scrap figure with high printing speeds presented great difficulties. This problem was solved by using the Dawe Type 1201E Stroboflood, a high-intensity stroboscope which may be triggered either at machine speed by the closing of a pair of contacts fitted on the machine under observation, or at a constant speed by the Type 1200E Stroboflash (a mains operated portable instrument having a range of 250 to 18,000 flashes per minute from a built-in oscillator). In this application it is actually triggered by contacts driven from the end of one of the printing rollers. The lamp is removed from the casing of the instrument and is mounted on a bar running the full width of the machine. The area immediately under the lamp, where the stroboscopic effect is strongest, is clearly shown in one of the photographs. As the lamp is automatically made to flash once for every revolution of the rollers of the press by the closing of the contacts, it is exactly synchronized with the press and will 'freeze' the print. This enables the operator to inspect the impression at any time to check that the colours register accurately and that the impression is even over the full width of the web. As adjustments can be made and their effects checked immediately without stopping the press, the critical weight of the impression, so important in this form of printing, can be obtained with comparative ease.

A typical application of the Stroboflash is the checking of wear on a commutator. Correct contact of brushes is of utmost importance in electric motors and generators. The stroboscope again permits visual inspection whilst the machine is operating, thus more frequent checks can be made since running time is not being wasted.

Another interesting example of the many uses of strobo-

Checking a rotating anode X-ray tube for acceleration and smooth operation with a Stroboflash in a matter of minutes. (Photo by courtesy of Mullard Ltd.)



scopes in industry is illustrated in another photograph showing the rotating anode of an X-ray tube which is being checked for acceleration and smooth running. The rotating anode works under difficult conditions. A great amount of heat is generated due to the electrons striking the periphery of the rotating anode, but conventional bearing lubricants cannot be used because the interior of the tube, in which the target and its driving motor run, is held at high vacuum in which conventional lubricants would vaporize and thus destroy the vacuum. Dry lubricants must therefore be employed. These are normally of a metallic nature and must ensure a minimum running clearance to obviate any 'bounce' at the bearings. Such bounce would be transmitted to the target (or anode) leading to enlargement of the tube focus and to the consequent blurring of the radiograph.

The 'Stroboflash' is used to 'slow down' this high rotary motion to an apparent slow speed such as 100 rev/min at which bounce can be easily detected. By varying the flashing frequency the rotating anode can be frozen and the number of flashes per minute which accomplishes this is exactly equal to the number of revolutions per minute at which the X-ray target is rotating. The speed of the rotating target can thus be measured.

The rate of acceleration of the rotor is a further important quantity which the Stroboflash can measure. The importance of acceleration may be gauged from the fact that a deviation of only 1% from the nominal figure of some 23,000 radians/sec/sec represents a very large quantity. Acceleration is found with the aid of a stopwatch by measuring the time taken for the rotor to reach a given speed as indicated by the Stroboflash.

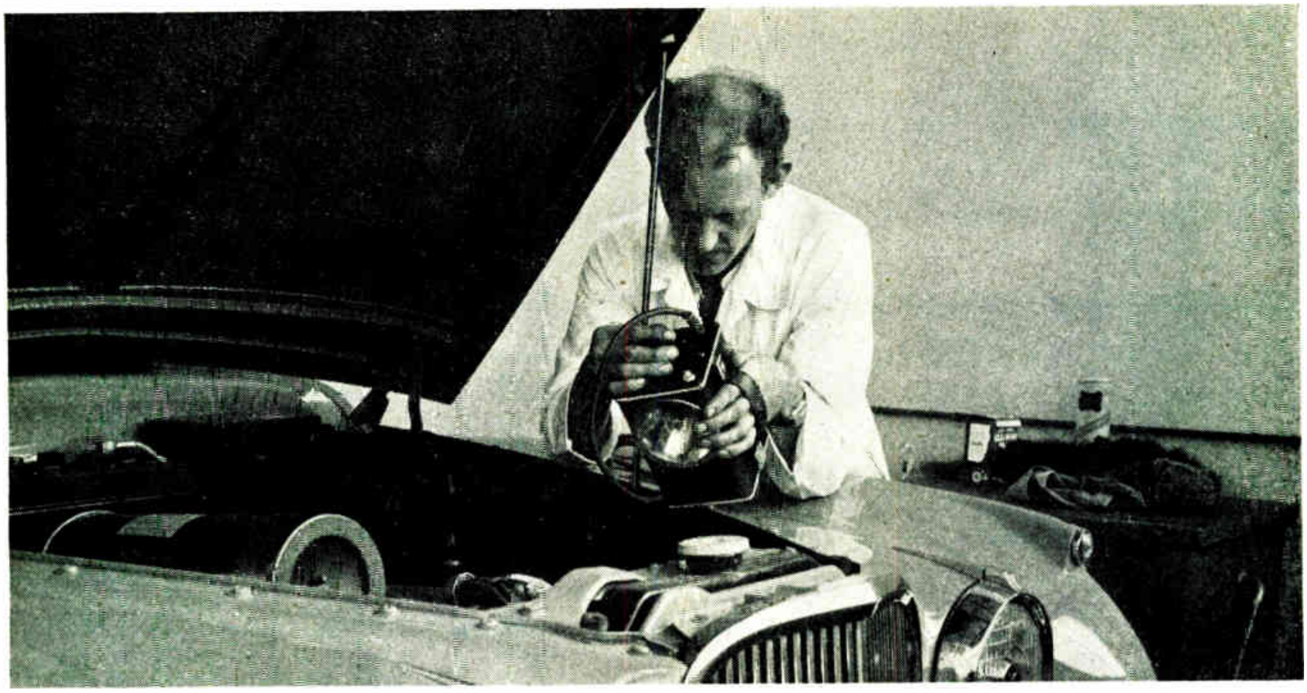
Although the range of flashing speeds of this particular stroboscope is 250 to 18,000 flashes per minute, enabling direct measurement to be made of rotating (or reciprocating) movements within that range, the practical upper limit of measurement is about 100,000 rev/min. This is possible by making the flashing speed a sub-multiple of the rotational speed under observation. Thus, to check a speed of, say, 90,000 rev/min the stroboscope is set to operate at 18,000 flashes per minute. The rotor is then illuminated at the same point of its cycle once every fifth cycle. This would provide an apparent freezing of the motion as in the normal way but, of course, the speed setting of the stroboscope must be multiplied by five or other appropriate factor, depending on the sub-harmonic used.

The Type 1205A High Frequency Stroboscope is an instrument designed to cope with the higher speed ranges. A range from 10 c/s to 10 kc/s can be covered in six stages so permitting stroboscopic inspection up to very high audio frequencies. Typical applications include the detection of resonance in the electrodes of thermionic valves on a vibration table, the study of gramophone pickups, loudspeakers, vibration generators and other electro-mechanical transducers, and the examination of really high-speed mechanical operation of such rotary devices as precision grinding, spindles and airborne compressor units. To permit 'freezing' of cyclical events at such frequencies, the pulse duration of the High Frequency Stroboscope can be reduced from 1 millisecond to as low as 3 microseconds.

Uniform Slow-Motion Effect

For certain applications—especially resonance search tests—it is desirable to obtain a uniform slow-motion effect, irrespective of the frequency of operation. A Slow-Motion Stroboscope, Dawe Type 1206A, has been specifically designed for this purpose. It enables the vibrating part to be viewed in slow motion at any selected speed up to 2 cycles per second, irrespective of the drive frequency. This avoids the difficult problem of keeping the vibration table and stroboscope operating at a small difference frequency and means that the main oscillator control can be swept through the required frequency range without having to make corresponding adjustment on the stroboscope. Points

A Slow-Motion Stroboscope makes objects appear to vibrate at a pre-set low frequency, irrespective of the true frequency of vibration



Checking for fan belt slip at various engine speeds

of resonance are immediately shown in slow motion and can be selected for closer study.

A miniaturized stroboscope which is portable and easy to operate has many applications in many industries. This is the Dawe Type 1210 Strobominor which has a built-in oscillator and is suitable for direct speed measurement from 600 to 7,200 rev/min and indirectly up to 50,000 rev/min. An illustration shows this simple stroboscope being used by a garage mechanic to study fan belt slip at various engine speeds.

Certain applications call for a stroboscope to investigate machines operating at normal mains frequency. The measurement of slip on induction motors by such a stroboscope, using mains frequency to trigger the tube, can be achieved by plugging the stroboscope directly into the same supply as the machine under investigation. The apparent rate of backward rotation of the motor then equals its slip, since the stroboscope is flashing at the synchronous speed.

The use of a stroboscope is, of course, possible only when the motion under examination is truly cyclical, every revolution being exactly similar to its predecessor. This applies to all but a few rotational movements and to many others, such as the operation of a petrol engine and a sewing machine, to name but two.

Tests such as the foregoing should prove specially useful on machine tools, although not all machine-tool manufacturers make an operational check to see that spindle speeds are actually as quoted. The stroboscope is the ideal tool for checking spindle speeds since in the process of freezing the motion of the spindle it will also show if the spindle is running smoothly, or if faulty bearings, out-of-balance or bad alignment are causing vibration.

STORAGE TUBE AIDS SURGEONS

BROKEN bones can be set in one-quarter the usual time with only one-hundredth the usual X-ray energy by using new electronic techniques pioneered by an experimental surgeon from Australia and his associates.

Dr. George Berci and his team from the University of Melbourne have worked for two years to build a 'stored telexray' system to aid surgeons in setting fractures.

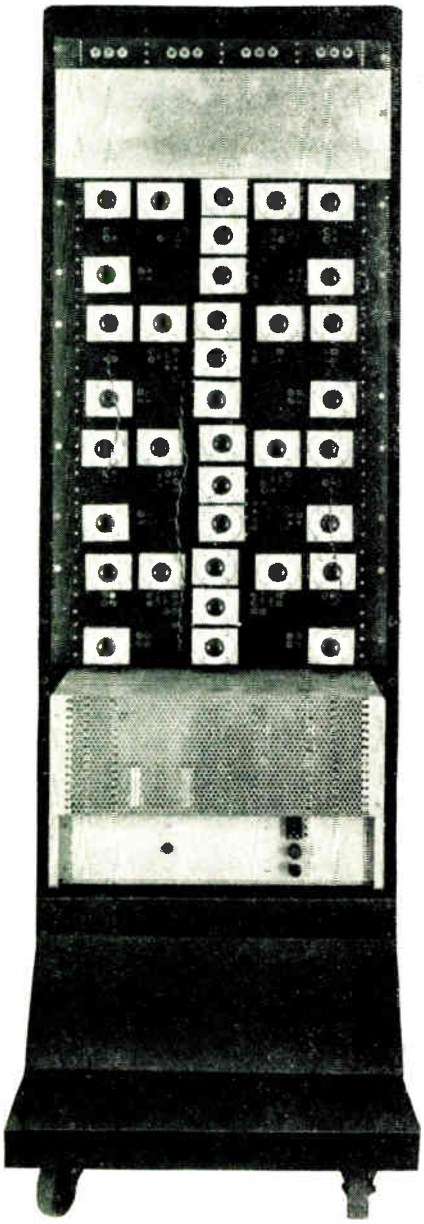
Starting with an X-ray tube, the information is amplified by an image intensifier for a brighter picture. This is then viewed by a vidicon television camera tube. Systems now in use do this, but a picture can be seen only while it is illuminated by X-ray energy and the patient and surgical team must be exposed to X-rays continuously.

A feature of the new system is a storage tube developed by Raytheon Company, U.S.A. The tube receives the picture of the broken bone from the television camera and in one-twenty-fifth of a second it stores the picture information on a fine mesh screen within the tube. Automatic cycling can be employed to take and store new X-ray pictures at intervals from 1 to 6 sec. The picture is then displayed on television monitors in the operating room.

As a further step it is planned to develop a four-picture storage unit. This would permit four X-ray pictures to be taken consecutively and stored simultaneously on one TV monitor which is divided into four sections so that views from two angles can be displayed side by side in the upper quadrants. The next pair of images could then be placed side by side beneath the first ones. Although each individual view could be enlarged to full-screen size at any time for closer examination, the instantaneous pairings will enable the surgeon to compare different stages of the operation or manipulation simultaneously.

TRANSISTOR

By K. LAMONT, M.I.R.E., and K. E. MOSS, B.Sc.*



The potentiometers and connecting sockets of the four panels for the four transistor simulators can be seen in this view of the complete equipment

A TRANSISTOR feedback amplifier has a behaviour with respect to changing transistor parameters which is more complex than that of a valve amplifier. Due to the inherent backward transmission and finite input impedance of the transistor, the forward and feedback paths are not clearly separable, and because of this the calculation of overall gain changes due to transistor variations may only be possible by the use of a computer.

The transistor analogue enables up to four 'synthetic transistors' to be built with any desired feedback configuration. Since each 'transistor' is made up of variable resistors and an idealized current generator which is also variable, the approximate behaviour of the complete circuit may be very rapidly assessed. The analogue is primarily concerned with the investigation of the effects of changing transistor current gain at a given frequency, rather than the effects due to changing frequency, and the apparatus operates at the fixed frequency of 200 c/s.

Each of the four synthetic transistors comprises a circuit which simulates a transistor. It includes controls which enable the 'transistor' parameters to be varied at will.

Transistor Equivalent Circuit

The normal T-equivalent circuit as shown in Fig. 1 is used to represent the transistors.

The function of the current generator is realized by a stable amplifier having high input and output impedances arranged as shown in Fig. 2. In order to avoid ambiguity, this amplifier will subsequently be referred to as the current generator.

It will be seen that some restrictions are thus placed on r_b and r_c' in that the former must be large enough to permit the chosen maximum value of β to be reached with a practical current generator. The effective value of r_c' is of course limited to the value of the output impedance. In the actual analogue the minimum value of r_b is 400 ohms, which allows a maximum value of β of 200; the output impedance of the current generator is 100 kilohms.

Though only common-emitter configurations are considered here, common-collector stages may be simulated equally well. Common-base stages can also be simulated, though the restriction due to the output impedance of the current generator might be significant in the case where a very high load is required.

Requirements for the Current Generator

It will be seen from Fig. 2 that none of the four terminals of the current generator may be earthed. Since more than one stage is concerned in the circuit to be simulated, the only point which may be earthed is that shown, since this is the only point common to all stages. In the circuit to be simulated, local feedback may be applied in significant amounts (e.g., by the addition of an external emitter resistor) and in such cases the condition will obtain in which the voltage between either input terminal of the current generator and earth may be large compared to that existing between them. This implies that the current generator must not respond to parallel (longitudinal or common mode) input signals but only to the push-pull signals. Since 40 dB of local feedback may quite conceivably be applied to the emitter

*Associated Electrical Industries (Woolwich) Ltd.

CIRCUIT ANALOGUE

This article describes apparatus which can simulate the behaviour of a transistor and which enables its effective parameters to be readily adjusted. It makes it possible readily to establish the effect of transistor tolerances on circuit performance.

of a transistor this means that a parallel or longitudinal component can exist which is 40 dB above the level of the wanted signal, appearing across the base-current monitoring resistor. In order, therefore, that the parallel component shall not modify the wanted push-pull component by more than about 1% the degree of parallel signal suppression must be of the order of 80 dB. [Fig. 6 (c).] The input signal is not one which is symmetrical with respect to earth and it is therefore not permissible for the current generator to have the centre point of its input side earthed since this would result in the introduction of a parallel signal. An input transformer of balanced construction in which the primary winding is unearthed is therefore necessary. In order to keep hum pick-up down to a tolerable level, the input transformer is astatically wound. Similar considerations apply to the output transformer, except that

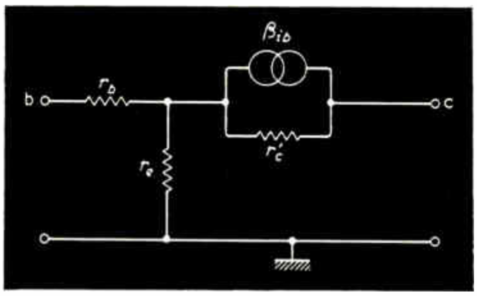


Fig. 1. Common-emitter equivalent circuit

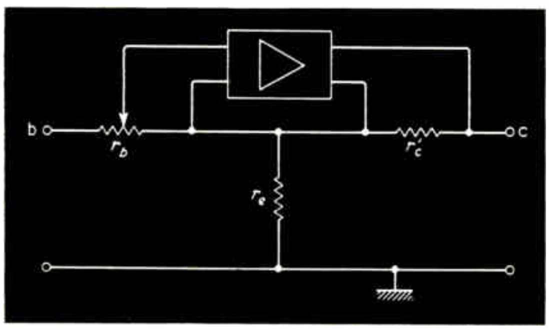


Fig. 2. Analogue of transistor

astatic winding is not necessary and the requirements for parallel signal suppression can be reduced. Since the stage will normally have appreciable gain, suppression is of the order of 60 dB and this is considered adequate. [Fig. 6 (d).]

Since all the current generators are fed from a single power supply it is important that no significant unwanted coupling shall take place by this route and so constitute an unwanted feedback path in the circuit to be simulated. The decoupling of each individual current generator is therefore arranged to suppress signals fed back via the h.t. supply by at least 100 dB.

The following specification was drawn up as representing the basis for a satisfactory 'current generator'.

1. Input impedance, greater than 50 kΩ
2. Output impedance, greater than 100 kΩ
3. Maximum current gain, 200
4. Output voltage, at least 10 V available into 1,000 Ω load
5. Parallel signal suppression at input, greater than 80 dB
6. Parallel signal suppression at output, greater than 60 dB
7. Attenuation to signal transmission between units via h.t. supply, greater than 100 dB
8. Equivalent noise referred to input terminals, less than 10 μV
9. Phase shift at working frequency, 180° ± 2°
10. Asymptotic phase shifts, 180° ± 60°.

The last characteristic is desirable in that coupling of up to three stages without instability is thereby facilitated.

Input Transformer

The input transformer assembly consists of a pair of similar sets of windings in opposite sense on a pair of mu-metal cores both enclosed in a common mu-metal can. Electrostatic screens were not used as adequate parallel signal suppression was obtainable by means of balanced construction without the introduction of additional, possibly unequal, capacitances. The details are shown in Fig. 3.

Output Transformer

The output transformer was wound on a two-section bobbin as shown in Fig. 4. Again it was found that satisfactory results were obtainable without electrostatic screens.

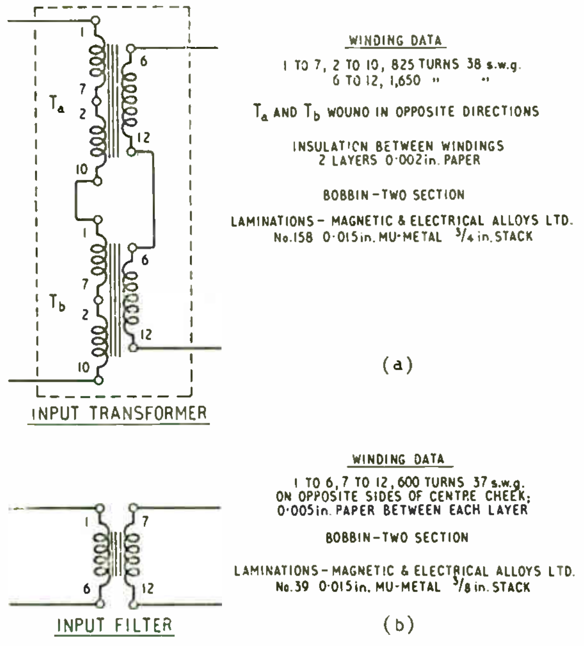


Fig. 3. Winding data for input transformer and filter

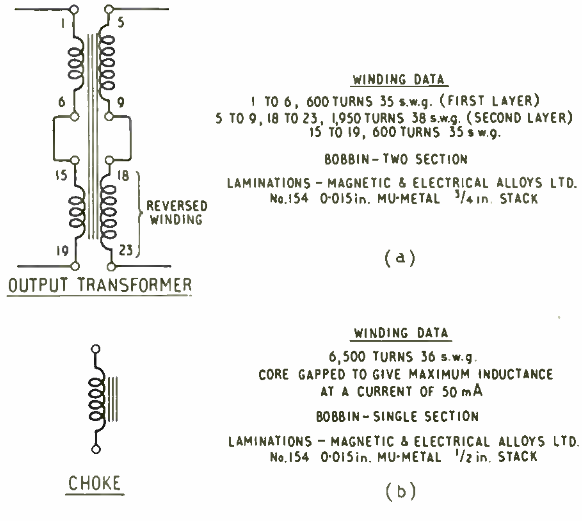
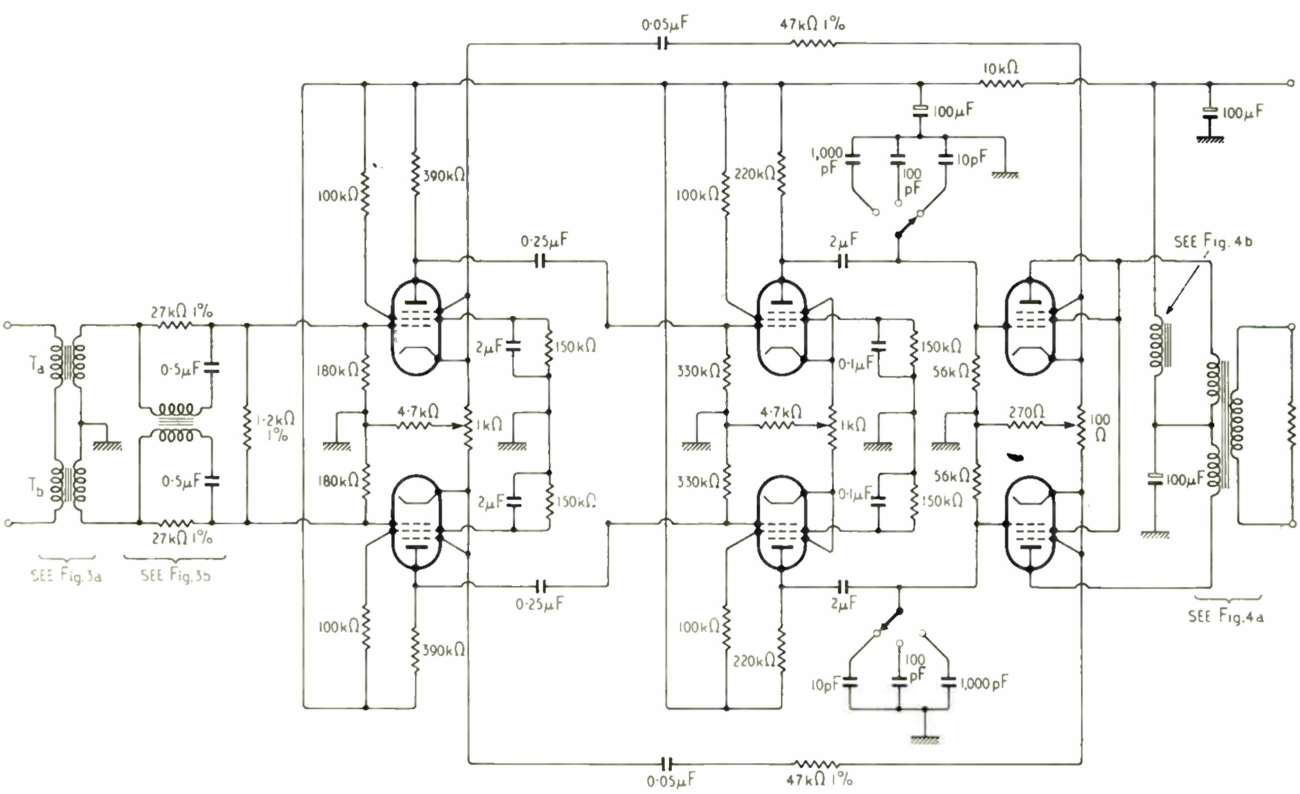


Fig. 4. Winding data for output transformer and choke

Transistor Circuit Analogue

Fig. 5. Circuit of amplifier which simulates the constant-current generator of Fig. 1



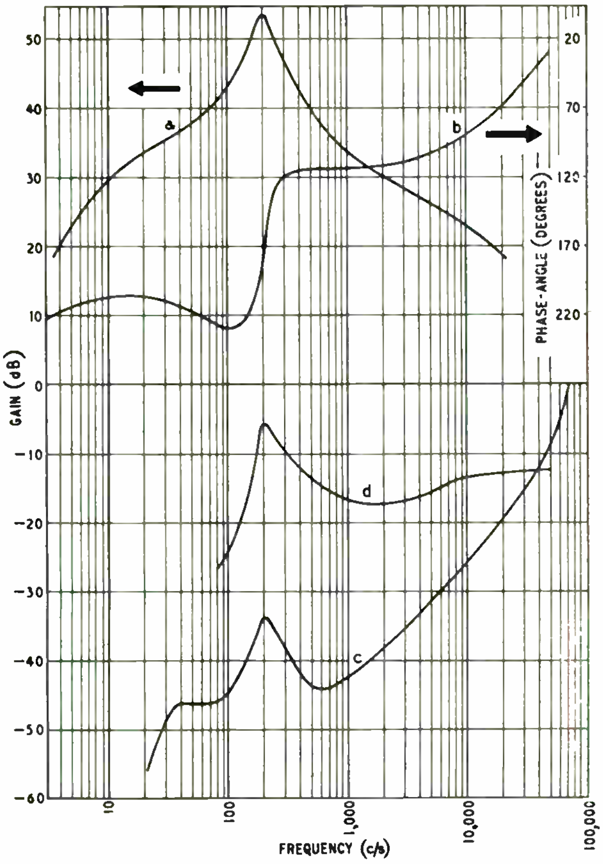
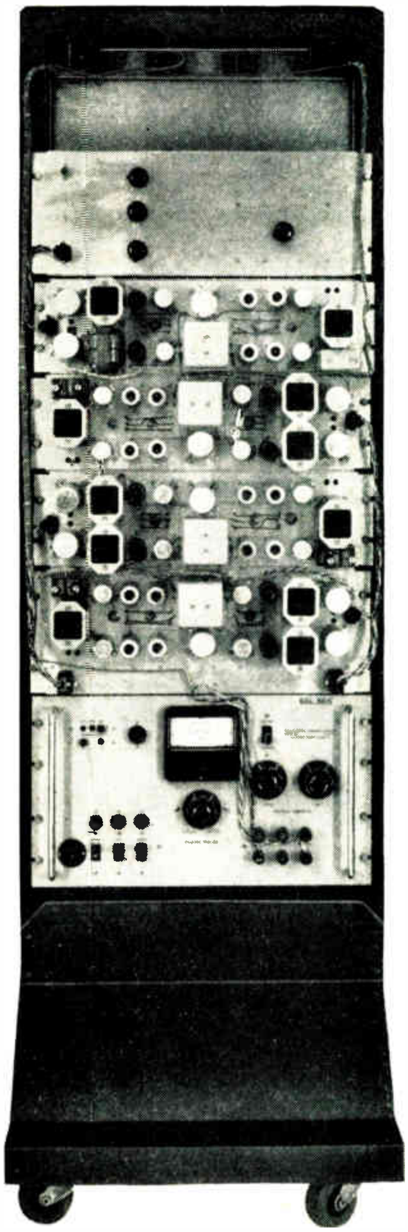


Fig. 6. Characteristics of current generator amplifier of Fig. 5 with a oad of 1,000 Ω



Rear view of the analogue showing the amplifiers of the current generators

Fig. 7. Voltage gain versus load resistance for the current generator

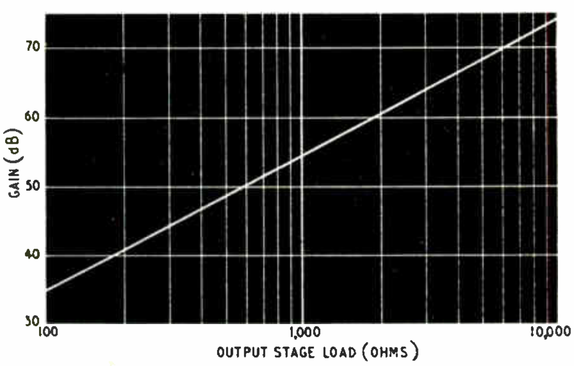


TABLE 2

Voltage Gain (dB)						Change in Gain (dB)	
Measured on analogue	Calculated		β_1	β_2	β_3	Measured on analogue	Calculated
		No overall feedback					
58	56·8	$Y_x = 0$	50	50	50	—	—
			25	50	50	−1·3	1·6
			100	50	50	+0·8	−1·0
			50	25	50	−2·9	−3·3
			50	100	50	−1·9	−2·3
			50	50	25	0·6	−0·6
			50	50	100	+0·4	+0·4
		20 dB overall feedback					
27·7	27·6	$Y_s = 0·013$	50	50	50	—	—
			25	50	50	0·12	0·24
			100	50	50	−0·05	−0·04
			50	25	50	−0·24	0·44
			50	100	50	+0·14	−0·15
			50	50	25	0·06	−0·12
			50	50	100	−0·02	−0·01
		30 dB overall feedback					
37·6	36·9	$Y_x = 0·04$	50	50	50	—	—
			25	50	50	−0·05	−0·04
			100	50	50	Not readable	−0·03
			50	25	50	−0·12	−0·15
			50	100	50	+0·09	−0·17
			50	50	25	−0·03	0·03
			50	50	100	Not readable	−0·01

The calculated figures were obtained by solution of the network equations of the equivalent circuit.

Conclusions

In the development of transistorized feedback amplifiers it is usually necessary to investigate a number of possible circuit configurations. From the point of view of sensitivity to transistor parameters, the transistor circuit analogue provides a quick means of assessing behaviour. While it was not intended to supersede digital computation entirely, the analogue reduces the need for such work except for the detailed investigation of chosen configurations.

The transistor analogue apparatus was initially constructed without many refinements in order that its usefulness could be assessed. After being in use for some four months it has been thought justifiable to improve its facilities, particularly by the incorporation of helical potentiometers to permit a higher degree of accuracy.

Acknowledgment

Acknowledgment is made to the Director, A.E.I. (Woolwich) Ltd. Research Laboratory, for permission to publish the paper.

NEW REMINGTON SYNCHROTYPEWRITER

The type 300 Synchrotypewriter perforates seven-channel paper tape as a by-product of invoice typing. By keeping tape units in slide-away drawers and continuous stationery feed and refold at the back of the desk unit, a completely uncluttered work service is provided for the operator

With two major additions to their range of Synchrotypewriter data capture electric typewriters, Remington Rand are now marketing a machine that is capable of handling any existing form of machine language—paper tape or cards.

The first improvement is a sterling multiplying unit. This has been added to the range of Remington/I.C.T. Synchrotypewriter 80 column card reading/punching machines. The inclusion of this unit enables the tabulator card reader to perform automatic multiplication as well as addition and subtraction. For instance, not only can invoices be typed and added automatically, but the extensions are now calculated automatically during the process.

This logical step forward means that this equipment is adaptable to provide a completely automatic invoice-typing station that will produce completed invoices at the press of a button. Among the many applications for this machine are automatic typing, pricing and extension of stock returns and cost records.

The second addition is the provision of a complete range of paper tape perforator and reader units. These are housed in slide-away compartments of a desk unit.

The back of the desk incorporates compartments for foldaway continuous stationery feed and refold.

Inbuilt features of the tape units include solid-state plug-in printed circuits. There are also effective mechanical and electrical safeguards against misoperation. Simple maintenance is provided by the easily replaced printed circuit boards and the use of plug-in components. Individual computer requirements present no problems since the tape units are available to suit all computers.

One of the most appealing features is a low cost telex, five channel tape perforator which can halve the cost of telex transmission.

For further information circle 56 on Service Card

By forming semiconductor junctions on to thin silicon films which are deposited upon more highly conducting substrates a reduction in the spreading resistance is obtained. The technique offers a potential improvement in the sensitivities of mixer and detector crystals and in the cut-off frequencies of varactor diodes.

Thin-film technique for improving

MICROWAVE DIODES

By *H. V. SHURMER, M.Sc., Ph.D., A.M.I.E.E.**

IN semiconductor microwave devices the capacitance is restricted by making the contact area small. This however leads to constriction of the flow of current with consequent introduction of spreading resistance, whose effects become progressively more serious with frequency. Techniques now emerging for the epitaxial deposition of films of semiconductors auger an improvement in silicon microwave devices by reducing the spreading resistance.[1]

The conventional form of point contact, assumed to be circular, is shown in Fig. 1(a) and that which is now considered is shown in (b). If the film in the second instance has the same resistivity as the thick layer in the first, spreading resistance is improved in the ratio

$$\frac{r'}{r} = \frac{4}{\pi} \times \frac{w}{a}$$

A theoretical lower limit to the film thickness is set at about 200 Å by the need to accommodate the depletion layer associated with the potential barrier, but practical limits may be considerably greater than this.

The configuration illustrated in (b) is an idealized situation. A metallic substrate would be the obvious choice but for the fact that thin films on metals are notoriously unstable. Silicon films have, however, been grown successfully on to more heavily doped silicon substrates, of at least an order of magnitude greater conductivity, and thicknesses down to 1μ have already been achieved.

The thin film formula quoted in Fig. 1 is accurate only if fringing effects may be neglected. This does not apply at the present state of the art for mixers and detectors, with width/radius ratios not far from unity. In order to obtain data on spreading resistance for such cases, a water bath analogue was devised, which simulated the field conditions encountered with circular contacts. The results of this experiment provided the curve of Fig. 2, in which spreading resistance is plotted for varying width/radius ratios as a fraction of its asymptotic value.

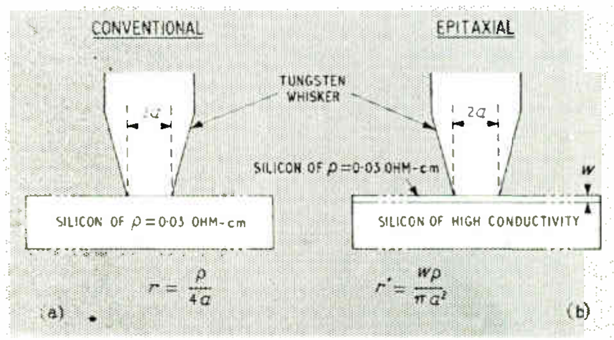


Fig. 1. Point contact diode structures

Mixer Crystals

To gauge the possible improvements in conversion loss for mixers employing epitaxial films, we have considered the latest form of contact as used in the silicon crystals

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VX4180/1, which are intended as replacements for the present standard inter-Services' mixers CV2154/5.

Part of a chart originally given by Baron[2] is reproduced in Fig. 3. This relates to mixers operating under image matched conditions and on it is plotted a point representing the VX4180/1 contact at 10 Gc/s. Through the point, inclined at 45° to the axes, is drawn a line along which is marked a scale of frequency. The conversion loss for the VX4180/1 contact at different frequencies is given by interpolation of the points in this scale with the set of curved lines which represent constant conversion loss for optimum drive.

A series of parallels to the straight line each represents the VX4180/1 contact modified to have a different spreading resistance, that for the original contact being taken as 25 ohms. The vertical lines which pass through points corresponding to the marked frequencies on the 25-ohm line cut these parallels at points corresponding to the same frequency with different resistances. The full and dotted sections of the lines of constant conversion loss are those of Baron, the dotted portions indicating a degree of uncertainty.

Considering a contact of the same physical nature as that of VX4180/1 but formed on to silicon deposited epitaxially upon a high conductivity substrate, spreading resistances were evaluated for films of different thicknesses by means of Fig. 2. The radius of contact was taken as $2{\cdot}7\mu$. Values for optimum conversion loss corresponding to these spreading resistances were obtained from Fig. 3 and are plotted for various frequencies (extrapolated up to 100 Gc/s) as a function of film thickness in Fig. 4.

It is seen that for films of the order $0{\cdot}1\mu$ the improvements which are available are about 1 dB at 10 Gc/s, 4 dB at 40 Gc/s and 7 dB at 100 Gc/s. Experimental mixers, incorporating epitaxial silicon of 1μ thickness and operating at 9·375 Gc/s, have shown improvements in conversion loss of about 0·7 dB over VX4180/1, in agreement with the value obtained from Fig. 4.

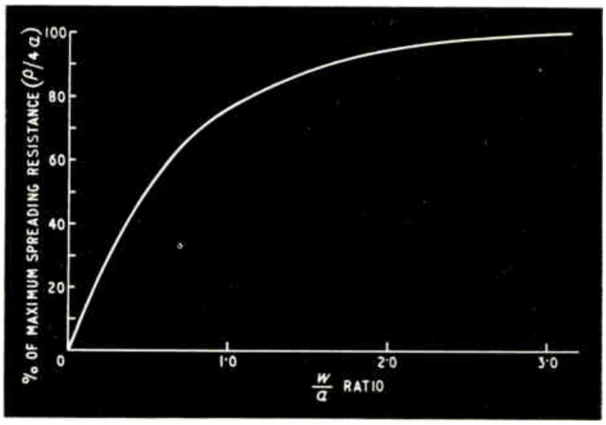

Fig. 2. Thin film spreading resistance for a circular contact

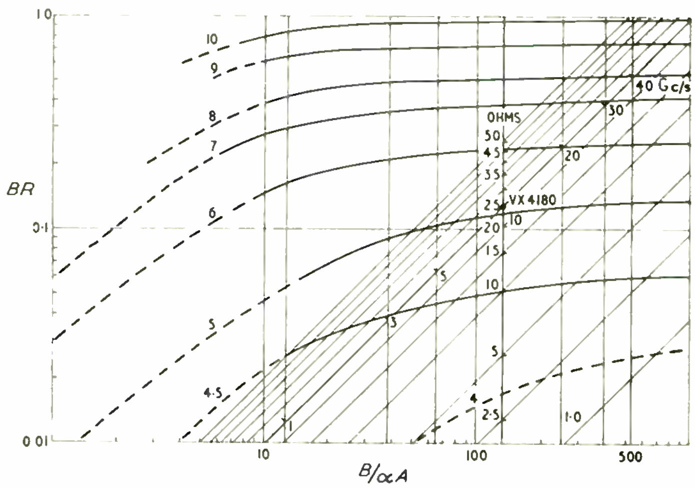

Fig. 3. Universal optimum conversion loss contours. This chart is reproduced by permission of the Controller of H.M. Stationery Office and Crown Copyright is reserved

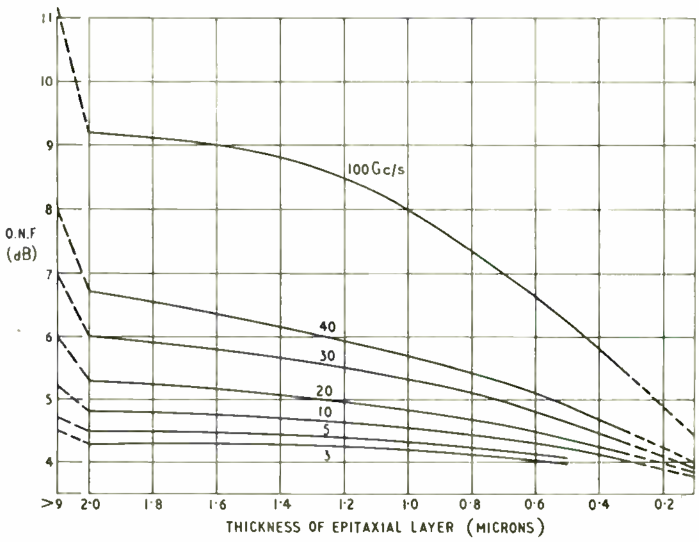

Fig. 4. Optimum conversion loss for VX4180/1 type contact

Detector Crystals

With detectors, the scope for improvement by epitaxial techniques is even greater than with mixers. The r.f. current sensitivity is given in terms of the low frequency value β_0 by the formula

$$\beta = \frac{\beta_0}{1 + \omega^2 C^2 Rr}$$

where ω = angular frequency
C = barrier capacitance
R = barrier resistance
r = spreading resistance.

For a given barrier resistance, the limiting sensitivity to small signals increases in proportion to β and, at frequencies above the 3-cm band, the formula shows that the current sensitivity increases almost proportionately to decrease in spreading resistance. We have calculated the sensitivities at various frequencies which would result from reductions in spreading resistance with thin films for two particular types of crystal contact.

One of the contacts considered was that used for the CV2355 type crystal, a high sensitivity detector intended primarily for the 3-cm band. The other contact was a more sensitive one used in experimental millimetre detectors type VX.4150. Properties assumed for these contacts are shown in Table 1.

Results calculated for the CV2355 contact are given in Fig. 5 as a series of curves of β plotted against film thickness for frequencies in the range 3–100 Gc/s. The thinnest film which is conceivable is one equal to the depletion layer and for both contacts this was estimated as 163 Å.

Maximum improvements found to be available with

TABLE 1

	C (pF)	R (ohms)	r (ohms)	a (microns)
(μA/μW)				
CV2355 10	0·16	4,000	28	2·68
VX4150 10	0·05	7,500	50	1·50

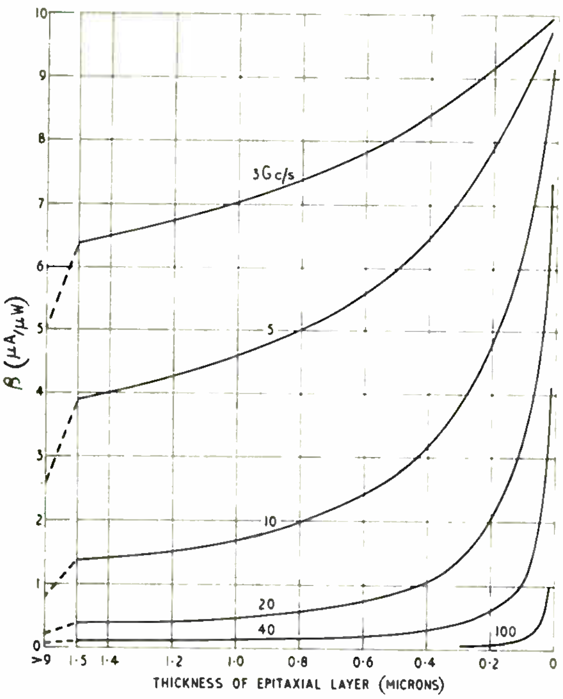

Fig. 5. Current sensitivity for CV2355 type contact with thin films

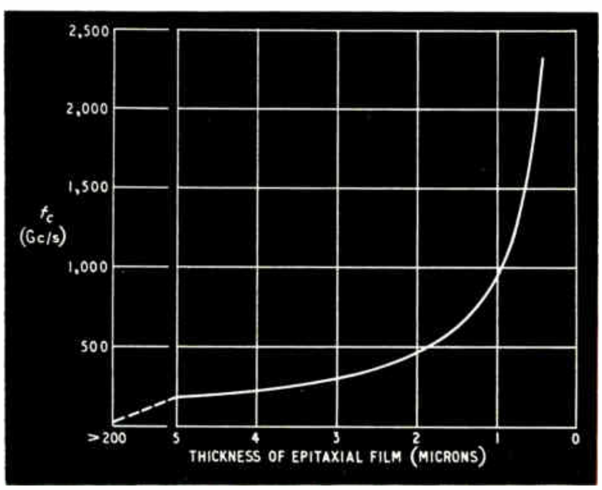

Fig. 6. Cut-off frequency for varactor diode with thin films

films of this minimum thickness over the normal form of CV2355 contact were 10·5 dB at 10 Gc/s, 18·8 dB at 40 Gc/s and 20·6 dB at 100 Gc/s. Corresponding figures for the VX4150 contact were 6·5, 15·2 and 17·7 dB, respectively, but it should be pointed out that the normal form of contact here is of appreciably greater sensitivity than for CV2355, although much more difficult to achieve. Experimental detectors, using 1μ epitaxial silicon, have been shown to be approximately twice as sensitive as normal CV2355 detectors at 9·375 Gc/s, a result which agrees with Fig. 5.

Varactors

Variable capacitance diodes (varactors) are made with silicon of somewhat higher resistivity than point-contact crystals and therefore appear likely to benefit also from thin-film techniques. We have accordingly considered what improvement in cut-off frequency their adoption could give for a particular varactor p–n junction of modest performance.

The assumed junction is of 3 mil diameter formed in silicon of 0·06 ohm-cm resistivity, with a depletion layer thickness of 0·42μ. The corresponding figures of 4 ohms spreading resistance and 1·25 pF capacitance agree with the published data for the lowest grade varactor of one manufacturer, with capacitance measured at −15V.

The spreading resistance corresponding to the same junction with thin films has been calculated as before and the results applied to the cut-off frequency formula

$$f_c = \frac{1}{2\pi rC},$$

assuming that no other significant series resistance is present. Fig. 6 shows the cut-off frequency as a function of film thickness and indicates that, even with this low performance junction, cut-off frequencies in excess of 2,000 Gc/s are available. Recent announcements indicate that values of around 150 Gc/s have so far been achieved with epitaxially deposited silicon.

Conclusions

Thin-film techniques are shown to offer great possibilities for more sensitive microwave crystals and varactors of higher cut-off frequency. Improved performance has been calculated on the assumption that thin films can be prepared to the same composition as the material currently in general use with these devices, deposited upon high conductivity substrates. Practical restrictions to the ideal conditions are naturally to be expected, but present progress indicates that close approximations may be realisable.

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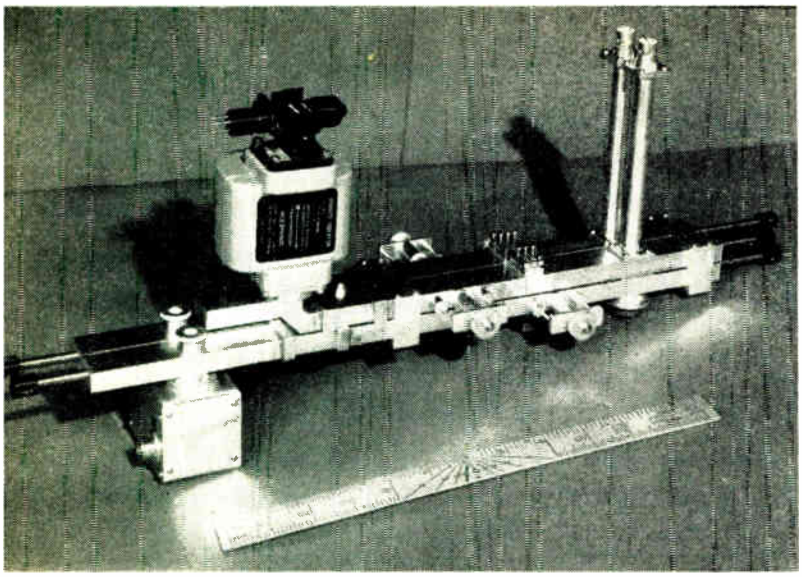


PARAMETRIC

General form of an experimental parametric amplifier and mixer

THE development of parametric amplifiers with their low noise characteristics has made it possible to boost the performance of radar equipment not subject to jamming.

The primary objective, in developing the parametric amplifier described here, was to achieve low-noise operation without impairing the operational stability of the Marconi Airways Surveillance Radar Type 264A. Earlier work in this field had been directed towards the development and testing of a 'single-port' reflection amplifier with circulator input. Field trials, although encouraging as regards sensitivity improvement, made apparent the inherent stability shortcomings. Moreover, in the particular embodiment used, pump, idler and signal frequencies were accommodated in the same resonator, thus some degree of compromise tuning was involved in setting-up. Work on an experimental up-converter, despite the increased complexity, was commenced with a view to overcoming, at least to some extent, the above-mentioned shortcomings.

Basic Principles

It has been demonstrated[1,2] that the requirements sought are not incompatible in the case of u.h.f. up-converters pumped at X-band. Although Weglein[3] computes an optimum idler/signal frequency ratio for lowest radar noise temperature, it will be shown later that, apart from the inconvenience in size resulting from the use of, say S-band pumping, other indispensable advantages are obtainable at higher pumping frequencies.

In the variable reactance up-converter the signal to be amplified f_s is mixed with a 'pump' signal f_p in a silicon diffused-junction diode; the up-converted output can be taken either at the sum-frequency f_{p+s} or the difference-frequency f_{p-s} where

$$f_{p+s} = f_p + f_s$$
$$f_{p-s} = f_p - f_s$$

There are at least three modes of operation available for use[4]:—

(1) Sum-frequency (upper sideband) up-conversion.
(2) Difference-frequency (lower sideband) up-conversion.
(3) A hybrid mode combining (1) and (2).

In the case of a lossless varactor coupling four frequencies (f_s, f_p, f_{p+s}, f_{p-s}) the Manley-Rowe[5] relations become

$$\frac{P_p}{f_p} + \frac{P_{p+s}}{f_{p+s}} + \frac{P_{p-s}}{f_{p-s}} = 0 \qquad (1)$$

$$\frac{P_s}{f_s} + \frac{P_{p+s}}{f_{p+s}} - \frac{P_{p-s}}{f_{p-s}} = 0 \qquad (2)$$

where $+P$ represents the average power entering the variable reactance and $-P$ the average power leaving the variable reactance at a particular frequency. Equations (1) and (2) assume that the variable reactance is reactively terminated at all other frequencies generated in the mixing process; in practice, this is achieved by providing resonant circuits incorporating the variable reactance at the frequencies of interest.

Assuming inputs at the frequencies f_p and f_s only, the available power gain from

$f_s \to f_{p+s}$ is

$$-\frac{P_{p+s}}{P_s} = \frac{f_{p+s}}{f_s}\,\frac{1}{1-\alpha} \qquad (3)$$

$f_s \to f_{p-s}$ is

$$\frac{P_{p-s}}{P_s} = \frac{f_{p-s}}{f_s}\,\frac{\alpha}{1-\alpha} \qquad (4)$$

where

$$\alpha = \frac{P_{p-s}f_{p+s}}{P_{p+s}f_{p-s}}$$

Now let us reconsider the three possible modes of operation.

(1) *Sum-frequency Mode*

Here we arrange to suppress the lower-sideband energy by presenting a low impedance across the varactor at this frequency. Thus $P_{p-s} = 0$, hence $\alpha = 0$ and (3) becomes

$$-\frac{P_{p+s}}{P_s} = \frac{f_{p+s}}{f_s}.$$

Thus the theoretical available gain for the upper-sideband mode is the ratio of frequencies; unconditional stability exists since the reverse loss always exceeds the forward gain. The gain available for a specific case, e.g., for $f_s = 600$ Mc/s and $f_{p+s} = 9{,}800$ Mc/s, is $G_{p+s} = 12{\cdot}1$ dB, which is ordinarily insufficient since in order to extract the radar information it is necessary to down-convert the amplified signal, and unless the up-converter gain is adequate (usually >16 dB) the down-converter will contribute significantly to the overall system noise factor.

(2) *Difference-frequency Mode*

Similarly in this mode the upper-sideband is suppressed relative to the wanted sideband, thus α can increase indefinitely in (4), P_{p-s}, P_s achieve the same sign implying that power leaves at both f_{p-s} and f_s and thus parametric gain

* Marconi's Wireless Telegraph Co., Ltd.

UP-CONVERTER RADAR

By F. J. GREGORY, B.Sc.*

An experimental parametric amplifier and mixer is described. It is designed to give low-noise operation with the Marconi Airways Surveillance Radar Type 264A.

occurs at these frequencies. This is a regenerative mode, negative conductance appearing at both the input and output terminals, and is consequently unstable. Beyond a certain level of pump drive the net input conductance becomes negative and spontaneous oscillation occurs.

(3) *Hybrid Mode*

The aim in using a so-called 'hybrid mode' is to augment that stable gain available due to up-conversion from f_s to f_{p+s} by a controlled amount due to regeneration. The coupling between the two sidebands occurs via the input signal which is enhanced by regenerative feedback from f_{p-s}. Clearly this mode can also yield instability under improper tuning conditions. Thus in order to maximize the available stable gain, f_{p+s} should be chosen to be as high as possible; furthermore, deamplification of the 'idler' (lower sideband) noise contribution increases as f_{p-s}/f_s increases. However, there are certain attendant disadvantages:—

(a) The pump power requirements increase as the square of frequency.

(b) The varactor cut-off frequency required must improve with pump frequency if pump power requirements are to be kept at a reasonable level. Penfield[6] (equation 72) shows that for a diffused junction diode the pump power required to achieve a given capacitance variation characterized by m is

$$P \simeq 6{\cdot}2\, m^2 P_n\, \omega_p^2/\omega_c^2$$

where ω_p = pump radian frequency.

$\omega_c = \dfrac{1}{R_s C_{min}}$ = varactor cut-off frequency.

R_s = diode series resistance.

C_{min} = diode capacitance at reverse breakdown.

P_n = a number characteristic of the varactor.

Therefore a compromise is necessary. X-band appears to be most suitable since pump sources of adequate rating are available as are varactors having suitable quality factors ($f_c \sim 90$ kMc/s).

Experimental Arrangement

In the experimental amplifier f_p was chosen to be 9·2 Gc/s,

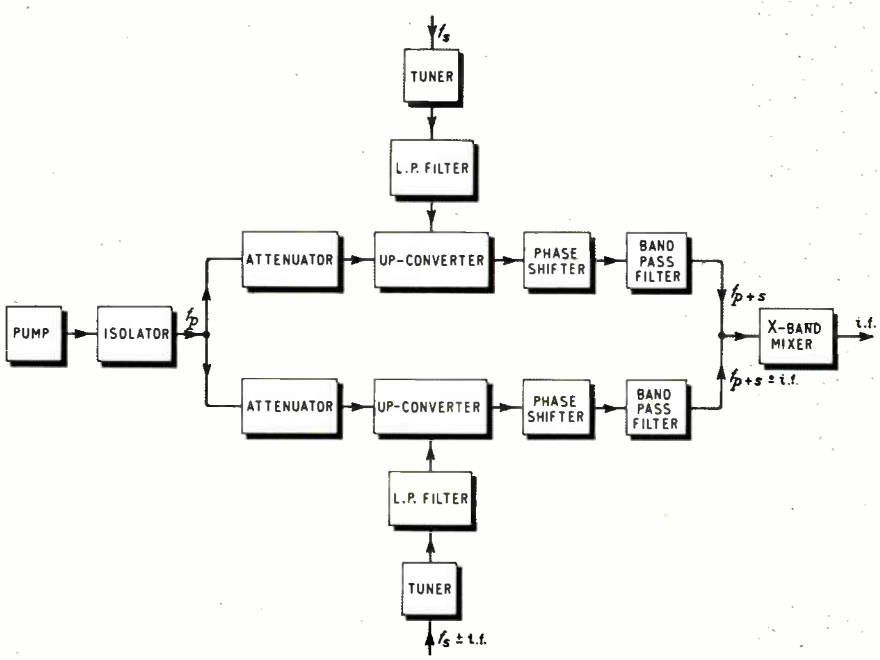
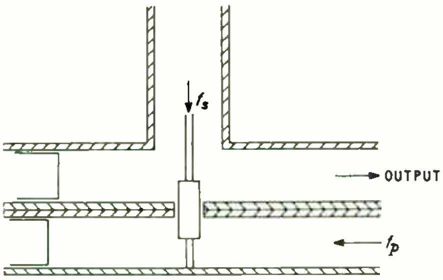
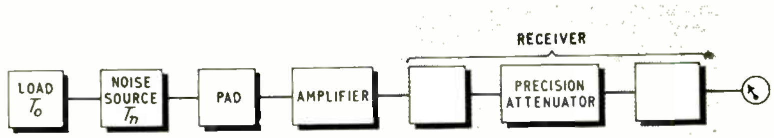


Fig. 1. Block diagram of experimental amplifier



Left: Fig. 2. Disposition of varactor

Below: Fig. 4. Arrangement for noise factor measurement



and thus for a signal frequency $f_s = 600$ Mc/s the relevant sidebands occur at 8·6 and 9·8 Gc/s, which lie in a relatively non-dispersive region of W.G.16 waveguide. Moreover, a balanced mixer, having a single-sideband noise factor ~9 dB, was available at the upper sideband frequency. Fig. 1 gives a block diagram and Fig. 7 and the photograph the actual arrangement.

Referring to Fig. 1 the arrangement comprises an X-band klystron as the pump source, a ferrite isolator and a 3-dB coupler which divides the pump power, one half proceeding along the upper (amplifier) arm, the other along the lower (synthetic local oscillator) arm. The pump power incident on the varactors is controlled by a variable attenuator in each arm. The 600-Mc/s signal to be amplified is introduced into one input arm, and a signal at 600 Mc/s less the i.f. into the other, each via a coaxial stub-stretcher and adjustable low-pass filter; the former matches the source to the varactor, the latter provides an X-band by-pass at the coaxial-to-waveguide transition. These coaxial inputs terminate in short-circuited varactors mounted in an aperture coupling two in-line waveguides (see Fig. 2).

Both waveguide pairs are terminated by short-circuit plungers; those in the input waveguides match the varactor at the pump frequency, those in the output waveguide together with the band-pass filters (centred at f_{p+s} and f_{p+s} + i.f.) provide an X-band resonator. Since the aim is to provide controlled regeneration using the lower-sideband f_{p-s}, a variable phase shifter is included between the output filter and the varactor, thus permitting variation of the coupling of the varactor to the lower-sideband frequency. The local-oscillator arm produces a suitable drive level for the X-band balanced mixer, and an i.f. output when combined with the upper-sideband output from the signal arm; this i.f. output is independent of pump frequency.

The initial step in the setting-up procedure involves the adjustment of the tuning controls in the local oscillator arm (pump power level ~20 mW; u.h.f. input level ~2 mW) to deliver an up-converted output at the level required for optimum mixer noise factor ($\simeq$9 dB is at present attainable).

In order to tune the signal arm it has been found desirable to frequency-modulate the pump klystron and observe the detected i.f. output on a synchronized c.r.o. Under the condition of minimum coupling to the lower-sideband power the output waveguide tuning can be adjusted so as to produce almost constant gain over the whole klystron mode. Additional regenerative gain is then obtained by adjustment of the lower-sideband coupling to the varactor using the phase-shifter.

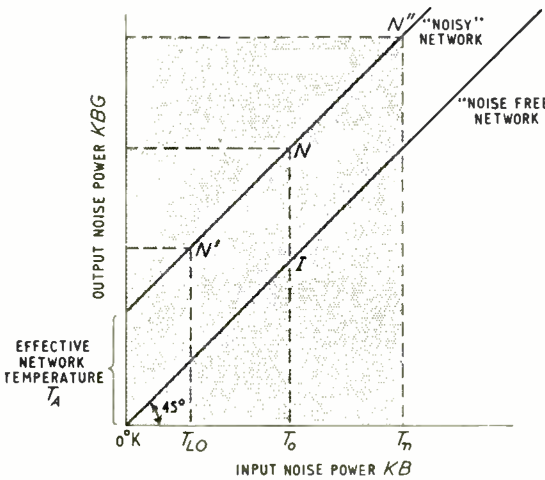
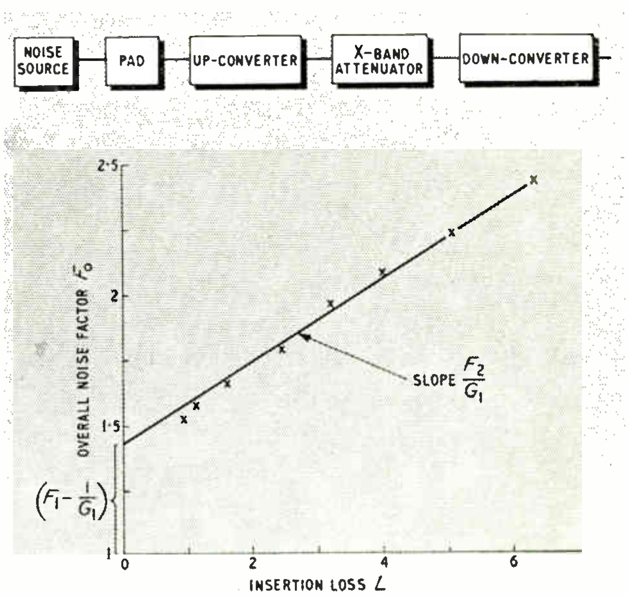


Fig. 3. Representation of effective amplifier temperature. K = Boltzmann's constant, B = bandwidth, noise factor = $1 + T_A/T_0$

Fig. 5. (Right) Measurement of up-converter gain and noise factor



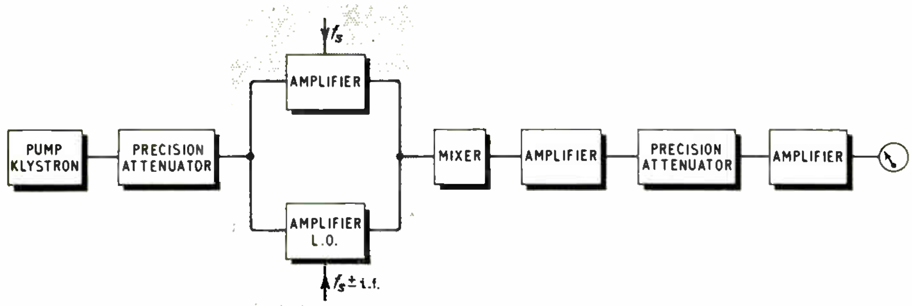


Fig. 6. Arrangement used for stability measurements

Measurement Techniques

(a) *Measurement of Overall Noise Factor*

The noise factor of a two-port network is normally defined as

$$\frac{\text{available noise power at the output terminals}}{\text{that portion of available output due to a matched source resistance at 290 °K.}}$$

The effective noise temperature of the network T_A is the temperature of the matched source resistance which connected to an equivalent but noise-free network would produce the same noise output as would the actual network when the source is at absolute zero.

These definitions can be illustrated graphically, Fig. 3.

The measurement of overall noise factor is commonly performed using a matched gas-discharge lamp as a wide-band noise source and observing the change in system output when the discharge is struck (Fig. 4).

One of the most serious errors likely to arise in noise figure measurements of parametric amplifiers employing regeneration is due to variations in amplifier gain resulting from small changes in input match. Techniques employing gas-discharge noise sources are particularly prone to error in this respect and the insertion of a well-matched attenuator ($\simeq$10 dB) between noise source and input is essential.

Moreover, in order to compute meaningful noise factors the discharge noise source output should be evaluated. This is most easily done by performing an additional noise-factor measurement, comparing the amplifier outputs when the input is connected in turn to matched sources, one at room temperature say, the other at 90 °K. See appendix.

In addition a noise diode (Rohde and Schwarz, Type SKTU BN 4151/2/50) was used for noise factor measurements, the three methods agreeing to $\pm$0·5 dB.

(b) *Measurement of Gain and Noise Figure of an Up-converter*

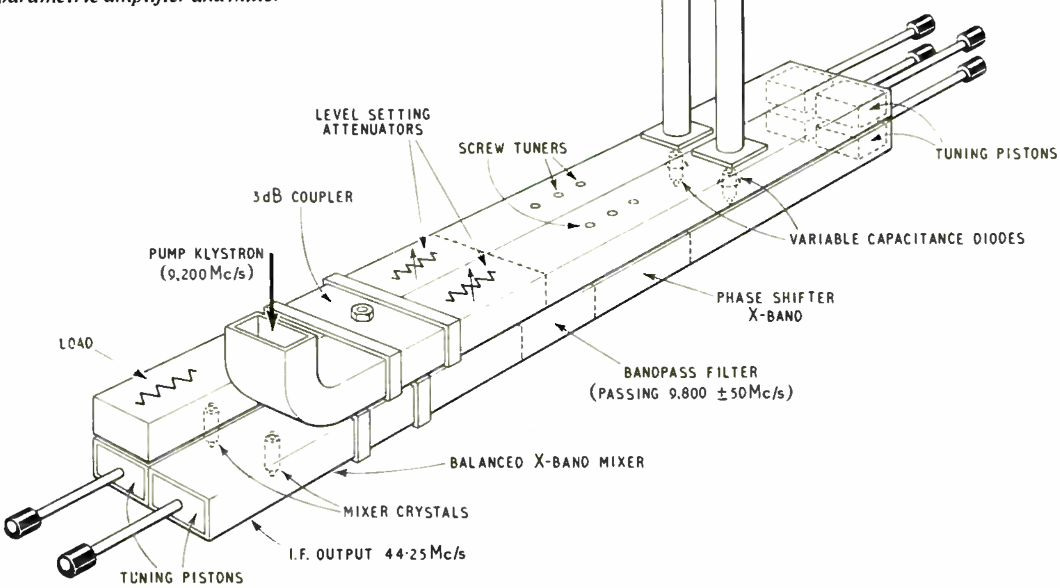
The noise figure F_1 of the up-converter is determined graphically from measurements on the overall noise factor F_0 of the up-converter/down-converter system. F_2 is the down-converter noise factor and L the attenuator loss, Fig. 5.

A plot of F_0 vs. L is made and the intersection of the line through the experimental points with the vertical axis (i.e., $L = 0$) yields $(F_1 - 1/G_1)$ and the slope equals F_2/G_1, since their sum is F_0; thus F_1 and up-converter gain G_1 are determined.

(c) *Measurement of Gain Stability vs. Pump Amplitude and Frequency*

Once the overall noise figure of the system has been reduced to an acceptable value, implying that the up-con-

Fig. 7. Details of Marconi experimental solid-state diode parametric amplifier and mixer



verter gain is adequate to reduce the noise contribution of the mixer significantly, there arises the question of the constancy of the gain at this level. Referring to Fig. 6, a known change in receiver output (second detector current) is made by introducing i.f. attenuation in the receiver chain, the necessary change in pump level to counteract this being measured by means of a precision attenuator.

The dependence of gain on klystron frequency is obtained by measuring directly on a calibrated wavemeter the frequency shift corresponding to a known change in output. In effect the measurements set the level of stabilization required both of the klystron power supply (reflector and heater voltage) and also of the klystron body temperature.

Experimental Results on Laboratory Model

Overall midband noise figures better than 2 dB (170 °K) are obtainable (this includes the noise contributions from the down-converter and that due to loss in the input tuner) at a gain of 18 dB. For operational use a compromise was sought, viz., an overall noise figure (2–2·5 dB) which was compatible with tolerable gain stability (arbitrarily taken as ±1 dB change in receiver output corresponding to ±5% change in pump amplitude). This compromise performance has been achieved and somewhat better figures have, on occasions, been obtained in the laboratory. Bandwidth exceeds 2 Mc/s, which is adequate for the intended application. The input tuner is probably the limiting factor.

In order to minimize the effects due to changes in klystron cavity temperature, laboratory tests were carried out with the klystron in a temperature controlled oven (≃35 °C) and gain variations were observed over periods of several hours; fluctuations did occur resulting in receiver output changes $< \pm 1$ dB.

The varactors used in these experiments were of the diffused-junction silicon variety. Typical characteristics were:—$C_0 \simeq 1{\cdot}5$ pF, $f_c \simeq 80$ Mc/s. The mixer diodes used were 1N23E, 1N23R.

Estimated Radar Range Improvement

In order to estimate the improvement in slant radar range resulting from a reduction in preamplifier noise figure from 7·5 dB to 2·5 dB account must be taken of the aerial temperature to which the preamplifier input is connected. Measurements performed on the Marconi S264A indicate an effective aerial temperature ≃120 °K.

Preamp. Noise Figure	Aerial Temp.	Effective Noise Temp.
7·5 dB (1,340 °K)	≃120 °K	1,460 °K
2·5 dB (226 °K)	≃120 °K	346 °K

Hence a signal/noise improvement of 1,460/346, i.e., 6·2 dB, is possible, which corresponds to a slant range improvement of 40 %.

Conclusions

Tests on a laboratory model of the parametric amplifier described indicate that, given adequate temperature control and stable power supplies, a noise figure better than 2·5 dB with adequate stability is possible at 600 Mc/s. It is essential for gain stability that a large proportion of the theoretical upper sideband gain is realized, to minimize the contribution due to regeneration, and this is also valuable in reducing the sensitivity of the amplifier to input match.

Acknowledgment

The author wishes to thank the Engineer in Chief and Dr. E. Eastwood, Director of Research, Marconi's Wireless Telegraph Co. Ltd. for permission to publish this article, and his colleague, Mr. A. Kwasieborski, for many helpful discussions.

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APPENDIX

Evaluation of T_X, the effective noise temperature of a gas-discharge tube

Matched loads at temperatures T_0, T_{L0} respectively are connected in turn to the input of a stable preamplifier followed by a receiver. The ratio β of the receiver outputs is measured.

Thus

$$\frac{T_0 + T_A}{T_{L0} + T_A} = \beta = \frac{T_0 N}{T_{L0} N'} \text{ (Refer to Fig. 3)}$$

hence

$$T_A = \frac{\beta T_{L0} - T_0}{1 - \beta} \quad (1)$$

where T_0 = 290 °K room temperature.
T_{L0} = 90 °K liquid oxygen temperature.
T_A = effective amplifier temperature.

The refrigerated load is now replaced by the gas-discharge tube which is connected via a matched precision attenuator to the preamplifier. The ratio α of the receiver outputs is again measured.

Here

$$\frac{T_X + T_A}{T_0 + T_A} = \alpha = \frac{T_X N''}{T_0 N} \quad (2)$$

where T_X = effective noise temperature of discharge tube

hence

$$T_A = \frac{\alpha T_0 - T_X}{1 - \alpha}$$

Combining (1) and (2) and solving for T_X,

$$T_X = \frac{\alpha\beta T_0 + \beta T_{L0} - T_0 - \alpha\beta T_{L0}}{\beta - 1}$$

in which T_0, T_{L0}, α and β are known or measurable quantities.

INDUSTRIAL NEWS

A. C. Butterfield is this year's president of the Radio and Television Retailers' Association and **A. R. Mitchell** is the new vice-president; with **K. Turner** as junior vice-president.

Elliott-Automation Ltd. announce the formation of a Flight Instrument Division to specialize in the design, development and manufacture of flight instruments. It is under the general management of E-A Flight Automation Ltd. H. Hanbury Brown has been appointed manager.

A licence agreement has been made under which **CIBA Ltd.,** Basle, have acquired manufacturing, sales and patent licences for the E-pak system of encapsulation of Joseph Waldman and Sons, U.S.A. It is on an exclusive basis for all countries except U.S.A., Canada, Mexico and Japan.

Joseph Lucas Ltd. are now members of the Electronic Valve and Semiconductor Manufacturers' Association (VASCA).

Personal and Company News

Advance Components Ltd. have acquired the share capital of **Nagard Ltd.** E. G. Wakeling continues as joint managing director of Advance, but becomes also managing director of Nagard, with F. R. Dawes, F.C.A., as director and general manager and M. J. G. Hinton, A.M.Brit.I.R.E., as research director. P. L. Sidey, B.Sc., A.R.C.Sc., general sales manager of Advance assumes responsibility for Nagard sales assisted by S. R. Jarvis. Nagard activities will continue at Belmont, Surrey, except for sales, which will be centralized with those of Advance at Hainault, Essex.

British Insulated Callender's Cables Ltd. have acquired from Mount Lyell Investments Ltd. their holding of shares in Metal Manufacturers Ltd., Australia.

Dunlop have taken delivery of the first **David Brown-E.M.I.** VTD 30 turret drilling machine. This embodies the Emicon B100 analogue positional control system with punched tape for the information input.

The manufacturing capacities of **Lexor Electronics Ltd.** and **Rytol Ltd.** have been integrated. Initially, all matters relating to the manufacture of electronic apparatus will be handled by Lexor at 25/31 Allesley Old Road, Coventry. Telephone: 72614.

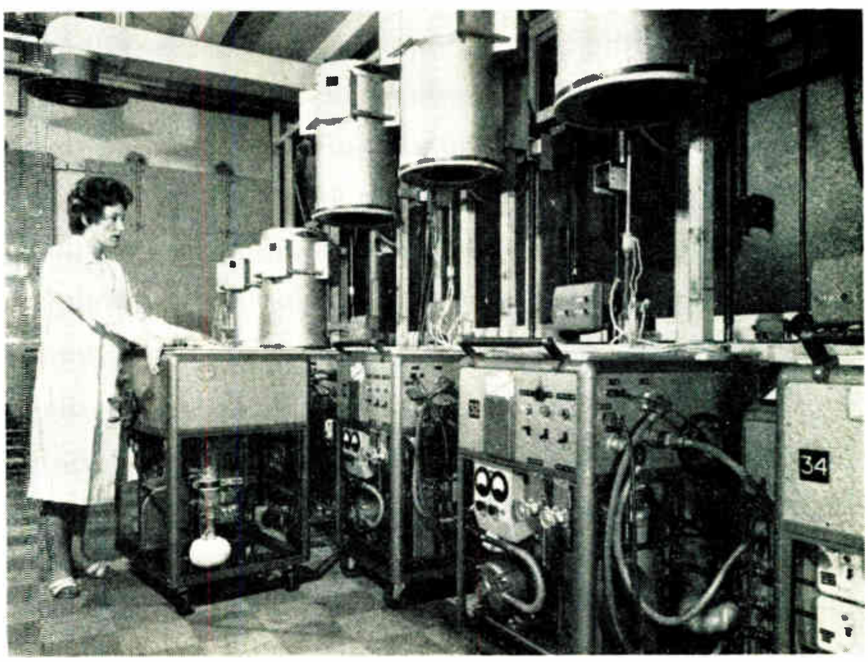
D. R. Holloway has been appointed commercial manager of Steelworks Automation Ltd.

Bush Radio have now received contracts for colour television apparatus which total nearly £70,000. The latest is from the B.B.C. for eight video monitors with separate and two with built-in signal decoders.

The Aviation Division of **S. Smith and Sons (Canada) Ltd.** have opened a branch office and warehouse near Idlewild Airport at 172-76, Baisley Boulevard, Jamaica 34, New York, U.S.A. (Telephone: Laurelton 8-1900).

Philip Smith has been appointed operations manager of the A.E.I. London Computer Centre.

Electrothermal provided an interesting link in a chain of events that led to the transmission of radio and television signals round the world via Telstar. The M-O Valve Company supplied travelling-wave tubes for use in the high-power transmitter at Goonhilly; Electrothermal provided the flexible heating mantles employed on the mercury pumps which evacuated these tubes. A number of mercury pumps used to evacuate travelling-wave tubes are shown here



Elcontrol photoelectric units of the Albro stopper-corking machine control the actuation of the pneumatically operated hammer. This picture shows how a cork flange interrupts the light beam between the MHL5 light source and MHP4 photoelectric cell

For further information circle 57 on Service Card

PERSONAL AND COMPANY NEWS (contd.)

Air Marshal Sir Herbert D. Spreckley, K.B.E., C.B., F.R.Ae.S., M.I.Mech.E., has been appointed military adviser to the Aviation Division of **S. Smith and Sons (England) Ltd.**

Norris Bros. Ltd. have moved to Burrell Road, Haywards Heath, Sussex (Telephone: Haywards Heath 2740).

George Kent Ltd. have acquired the whole issued share capital of **Alto Instruments (Great Britain) Ltd.,** manufacturers of electromagnetic flow-meters and associated equipment.

Following the acquisition of Murphy Radio by the **Rank Organization,** the production of the Murphy factory at Skegness is to be increased. It will produce for Bush Radio as well as Murphy Radio.

A.E.I. Ltd. is opening a new computer centre at 33 Grosvenor Place, London.

Obituary

P. A. Sporing, O.B.E., M.Sc., A.R.I.C., died on 10th November. He was general manager and director of The Telegraph Condenser Co. Ltd., which he joined in October 1923.

Electrical Engineers Exhibition

The 1964 exhibition will be held at Earl's Court, London, from 18th to 25th March 1964 and will be open from 10 a.m. until 7 p.m. except for 19th March when it will close at 9 p.m. For the first time overseas manufacturers will be able to participate.

Piezoelectric Fluorescent Crystals

New synthetic crystals which are both piezoelectric and fluorescent have been synthesized in the Bell Telephone Laboratories. They are small single-crystals of rare-earth aluminium-borates and rare-earth chromium-borates and they are produced by slowly cooling a molten solvent saturated with the oxides.

Tunnel-Diode Computer Store

Dr. G. B. Chaplin and his associates at Roke Manor, the applied research laboratory of The Plessey Co. (U.K.) Ltd., presented a paper in February 1961 at the International Solid States Conference at Philadelphia in which the principle of the tunnel-diode store was formulated. Since then the basic ideas have been developed into a fully-engineered store.

The tunnel-diode can change state in under 1 nsec and the first store demonstrated has a capacity of 32 words of 16 digits and a complete cycle of operations takes only 175 nsec. Although the tunnel-diode is more expensive than a ferrite core the circuitry is much simpler and this more than offsets the extra cost of the diodes for the smaller stores.

London International Engineering Exhibition

This is the new title of the Engineering, Marine, Welding and Nuclear Energy Exhibition which will be held at Olympia and Earl's Court, London, from 23rd April to 2nd May 1963. The organizers are F. W. Bridges and Sons Ltd. and Industrial and Trade Fairs Ltd.

Beryl Crystals

Bell Telephone Laboratories have developed a method for growing large beryl single crystals. Such crystals ($Be_3 Al_2 Si_6 O_{18}$) with chromium impurities are emeralds. Dehydrated beryl is placed in a platinum crucible and small amounts of berylium-oxide and ammonium-chromium-sulphate are added. The crucible is filled with vanadium-pentoxide and placed in a furnace so that the bottom is heated to 1,050 °C but the top to 1,000 °C only.

The beryl at the bottom dissolves and then crystallizes on to a seed plate hung in the upper part. The crystals are resistant to thermal shock and can be grown in large batches and removed quickly from the solution to room temperature.

Graduate Courses

The University of Birmingham is holding graduate courses of 12 months' duration from 1st October 1963 to 30th September 1964 and students who hold an approved first degree or Diploma in Technology may qualify by examination for the degree of M.Sc. The course normally includes five out of 14 subjects. Some of the most popular are Information Engineering, Electrical Machines and Air Traffic Engineering. Further information and application forms are obtainable from The Registry, The University, Birmingham 15.

Scintillation Counters

The Sir John Cass College, London, is planning a series of courses on the theory and practice of the scintillation counting of radioactive materials. They are being arranged by F. H. Kendall, B.Sc., Ph.D.(Lond.), F.R.I.C., and will start in March 1963. They will be held in a laboratory of Panax Equipment Ltd. at Redhill, Surrey. Each course will last for three weeks.

National Lending Library

The National Lending Library for Science and Technology was officially opened on 5th November 1962. It is at Boston Spa, Yorkshire, and already contains 350,000 volumes. The aims of the library are to augment existing library services with a fast, return-of-post, loan service for Britain's research scientists and practising technologists and to promote the effective use of scientific literature. The library is not intended for students, nor has it an inquiry service. Although organized by the Department of Scientific and Industrial Research, it is not confined to subjects in which D.S.I.R. is interested but includes, for instance, medical material.

The library lends only to institutions. Volumes are stored under the first key word of the title only. A feature of the library is the large collection of Russian literature and translations,—the largest in Western Europe.

New Laser

Normally, a laser is excited by a high-intensity light source and produces a beam of coherent light. Gas masers can be excited by an electrical discharge. A new laser uses a gallium-arsenide junction and is excited by an electric current. The current injects electrons and holes into the junction and a directional and coherent infra-red beam (8,400 Å) is emitted from the edges of the junction plane.

The current is some 20,000 A/cm^2 and to prevent overheating it is pulsed and the crystal is cooled by liquid nitrogen or helium. The advantage of current excitation is that it lends itself readily to modulating the light output.

Two types are being developed, and are expected to be available for experimental purposes in the near future. One produces coherent light, the other non-coherent. The latter is stated to be nearly 100% efficient.

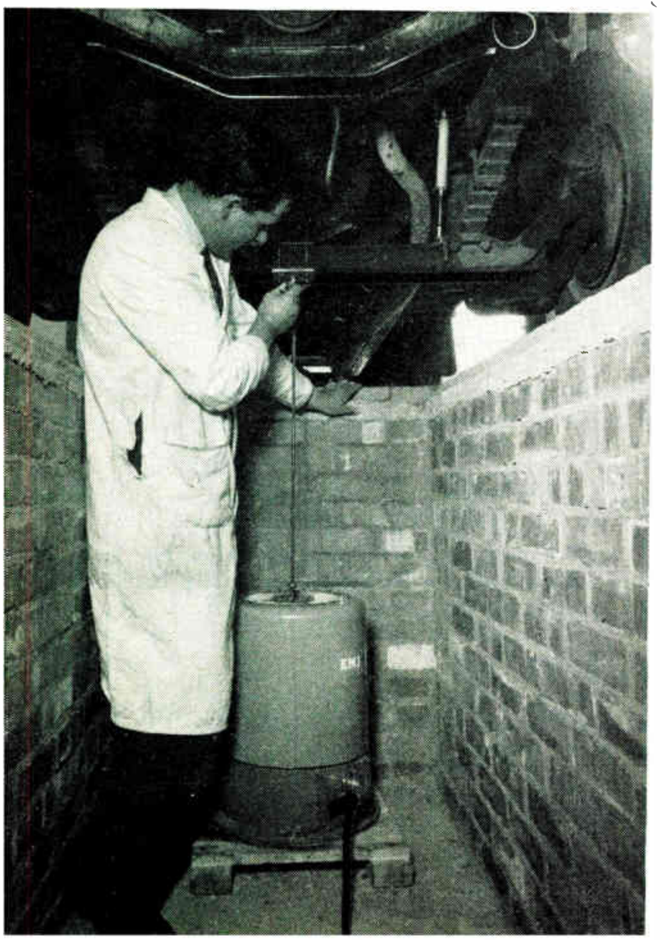
The development has been carried out in the General Electric Research Laboratory, Schenectady, N.Y., U.S.A.

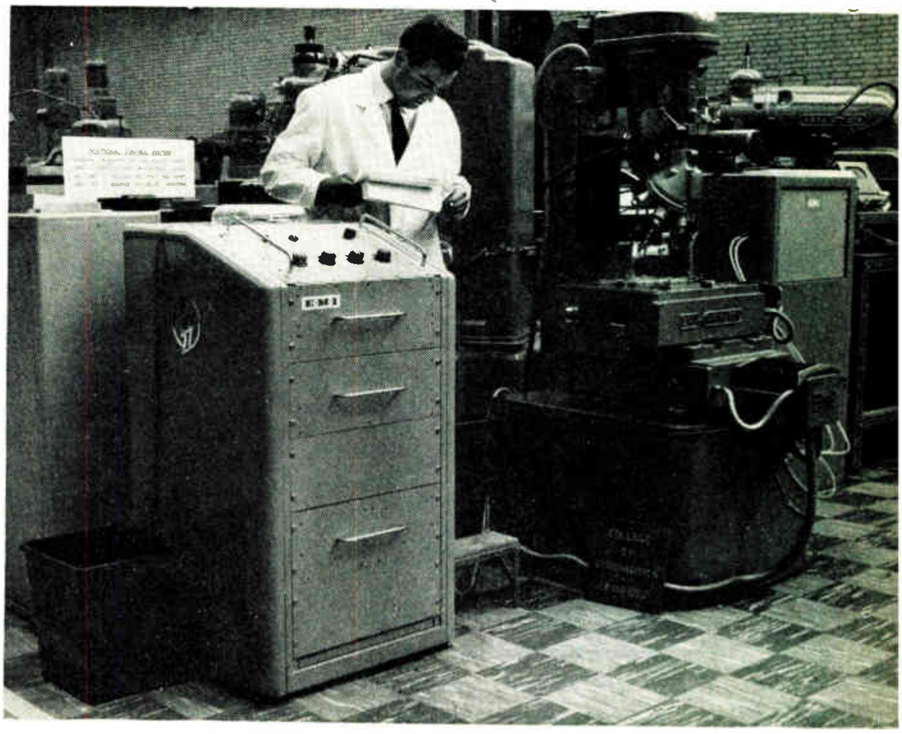
A.S.E.E. Diploma Examinations

Entry applications should reach the General Secretary by 1st March 1963. The written section of the examination will be held between 15th and 31st March 1963 and the oral section between 7th and 9th May. The subjects are Electrical Installation Practice, Electrical Maintenance Practice and Industrial Electronics and Control.

Electronic apparatus now finds wide application in training. *The E.M.I. vibration generator (left) is used at the Advanced School of Automobile Engineering, Cranfield. It is shown connected to a lorry axle. The school carries out post-graduate training, and theoretical work is supplemented by practical testing. The picture on the right shows a Meddings Pacera M8 turret-drilling machine for the batch production of small components. It is fitted with an electronic-control system developed by E.M.I. Electronics Ltd. which operates on numerical information punched on paper tape to control the machine for a sequence of operations. The equipment has been supplied to the College of Aeronautics, also at Cranfield, for the instruction of students in the behaviour of electronically-controlled machine tools*

For further information circle 58 on Service Card





Correspondence

Extending the Use of the Smith Chart

Sir,—The Smith chart provides a means of solving transmission-line problems without the necessity of performing lengthy calculations. The Smith chart has the advantage over other charts in that it is completely enclosed within a circle. However, when impedances with negative real parts are considered, the chart must be extended outside of the original boundary circle. This is inconvenient in that such charts are not readily available, and also that the chart is now infinite in extent.

The following describes a method by which the normal Smith chart may be used to solve transmission-line problems involving impedances with negative real parts. The impedance seen at the generator end of a transmission line is given by

$$Z = Z_0 \frac{Z_r + Z_0 \tanh \gamma}{Z_0 + Z_r \tanh \gamma} \qquad (1)$$

where Z_r = impedance at load end of line.
Z_0 = characteristic impedance of line.
γ = propagation constant $\alpha + j\beta$.
α = attenuation in nepers.
β = phase shift in radians = $2\pi d/\lambda$.
λ = wavelength.
d = length of line.

Suppose $Z_r = -R + jX$, then on substituting this in (1) and rearranging signs we arrive at the expression:—

$$-Z = Z_0 \frac{(R - jX) + Z_0 \tanh(-\gamma)}{Z_0 + (R - jX) \tanh(-\gamma)} \qquad (2)$$

This calculation may be handled on the Smith chart because the real part is now positive. Note that to perform the calculation, the signs of γ and Z_r are both reversed, and the answer is $-Z$. The steps to be taken are therefore:—

(a) Reverse the sign of both real and imaginary parts of Z_r.
(b) Perform the calculation on the Smith chart, remembering to reverse the phase rotation and to change attenuation to amplification.
(c) Reverse the sign of both real and imaginary parts of the answer to obtain the required result.

The Smith chart is the complex plane of the complex reflection coefficient defined by the following equation:—

$$\rho = \frac{Z - Z_0}{Z + Z_0} \qquad (3)$$

Substituting for Z from (1) and simplifying gives:—

$$\rho = e^{-2\gamma}\rho_r \qquad (4)$$

where

$$\rho_r = \frac{Z_r - Z_0}{Z_r + Z_0}$$

The calculation on the Smith chart may now be divided into two classes, the first for lossless lines (negligible attenuation) and the second for lossy lines.

(1) Lossless Lines

In this case the propagation constant is pure imaginary, since $\alpha = 0$. Thus from (4) it is apparent that the *magnitude* of ρ is unchanged, since the magnitude of the exponential term is unity for a pure imaginary exponent. The calculation on the chart is therefore performed by moving *anti-clockwise* around a circular arc which subtends an angle 2β at the centre of the chart. Usually the chart has its

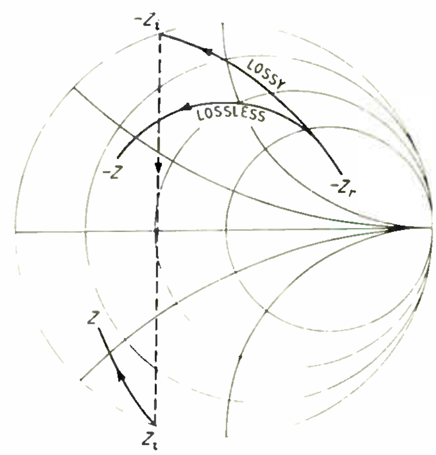


Fig. 1

circumference marked in wavelengths, making it unnecessary to calculate β. See Fig. 1.

(2) Lossy Lines

As in the case of calculations with positive real parts, the calculation for lossy lines is complicated by the fact that the magnitude of the exponential term is no longer constant. The calculation on the chart is performed by moving anti-clockwise around an equiangular spiral which subtends an angle 2β at the centre. Note that the spiral moves outwards, since the sign of γ has been reversed.

If the line is sufficiently long the spiral will intersect the chart boundary. If this occurs the spiral must be terminated at this point. The true impedance seen at this point is obtained by reversing the sign of the value shown on the chart. This value, which will be pure imaginary, is reinserted on the chart and the spiral continued *clockwise* and *inwards* until the total angle subtended by both spirals is 2β. The value on the chart is the correct answer, no reversal of sign being necessary. See Fig. 1.

The question of stability did not arise using this method of calculation. However, unless the transmission line is loaded with sufficient positive resistance, instability in the form of oscillations will occur. Also an arrangement apparently stable at one frequency does not guarantee stability at any other frequency.

The method described enables transmission-line calculations involving impedances with negative real parts to be handled on the normal Smith chart. It should be particularly useful for circuits employing tunnel diodes at high frequencies.

B. R. Davis.

Electrical Engineering Dept.,
University of Adelaide,
South Australia.

2MT Writtle

Sir,—The 2MT transmitter, from which test programmes were broadcast in February 1922, from the Writtle establishment of Marconi's Wireless Telegraph Company Limited, is frequently mentioned in correspondence and it has occurred to me that you may be interested to have an authentic description of this transmitter.

The transmitter circuit was based on that of the Croydon Aerodrome ground-station transmitter which was designed by Mr. P. P. Eckersley in late 1919 and early 1920. When the Writtle Experimental Establishment of the Marconi Company was requested to produce a transmitter there was, therefore, no difficulty in design work. We simply used the standard Marconi circuit of those days.

At the beginning of the transmissions on the 14th February 1922, the transmitter operated on a wavelength of 700 metres with an approximate power to the aerial of 200 watts.

The aerial was of the four-wire inverted-L configuration, supported by two 110 ft Marconi portable masts and was 140 ft long.

The circuit of the transmitter is depicted below. It will be observed that the radio-frequency circuit was of the self-oscillatory variety using a reaction coil coupled to the main tank circuit, the reaction coil being tuned to 0·7 of the operating wavelength. The aerial tuning coil consisted of an ebonite slat former wound with 243/36-stranded cable. This was magnetically coupled to a primary tuning circuit, the inductance of which was wound with 729/44-stranded wire. This inductance is shown on the left of the photograph. The closed-circuit condenser consisted of a stack of zinc plates separated by ebonite insulators. This was situated under the bench on which the inductance was mounted.

In order to obtain the correct anode impedance, a tightly coupled secondary winding, consisting of a coil of No. 20 gauge wire, was wound over the primary tuning inductance. This is evident in the photograph on page 182.

The circuit was shunt-connected to one M.T.4 triode, which was a standard Marconi valve at the time. Amplitude modulation was effected by a Heising circuit, one M.T.4 being used as a modulator and another as an amplifier. In the first few transmissions the microphone was directly connected to the grid of this valve.

The anode high-tension, at 8,000 volts, was supplied by two M.R.1 valves in bi-phase connection. The valves and high-tension transformer are also shown in the photograph.

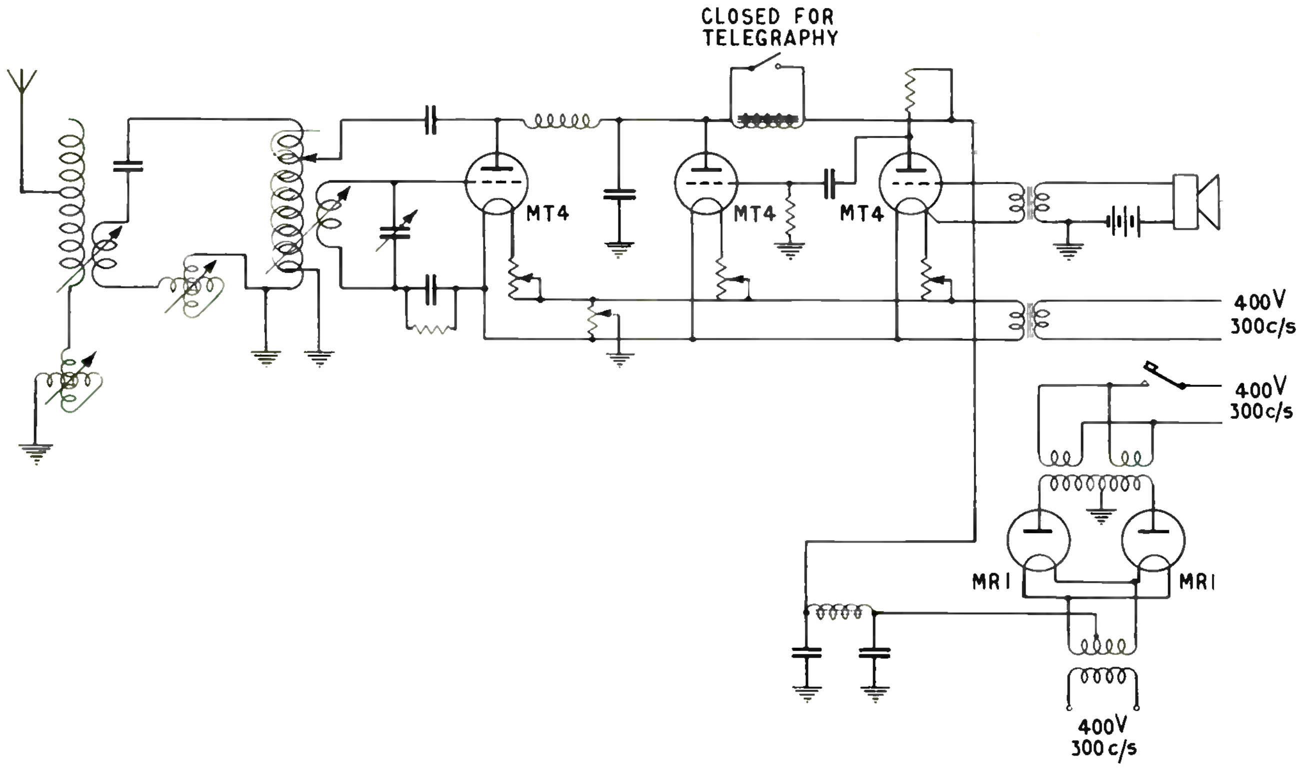
The primary supply to the high-tension transformers and the filament transformers was supplied by a 400-volt, 300 c/s, single-phase alternator, driven by a 110-volt d.c. motor which received its supply from two 4½-kW, 110-volt, petrol engines (four-cylinder Austins).

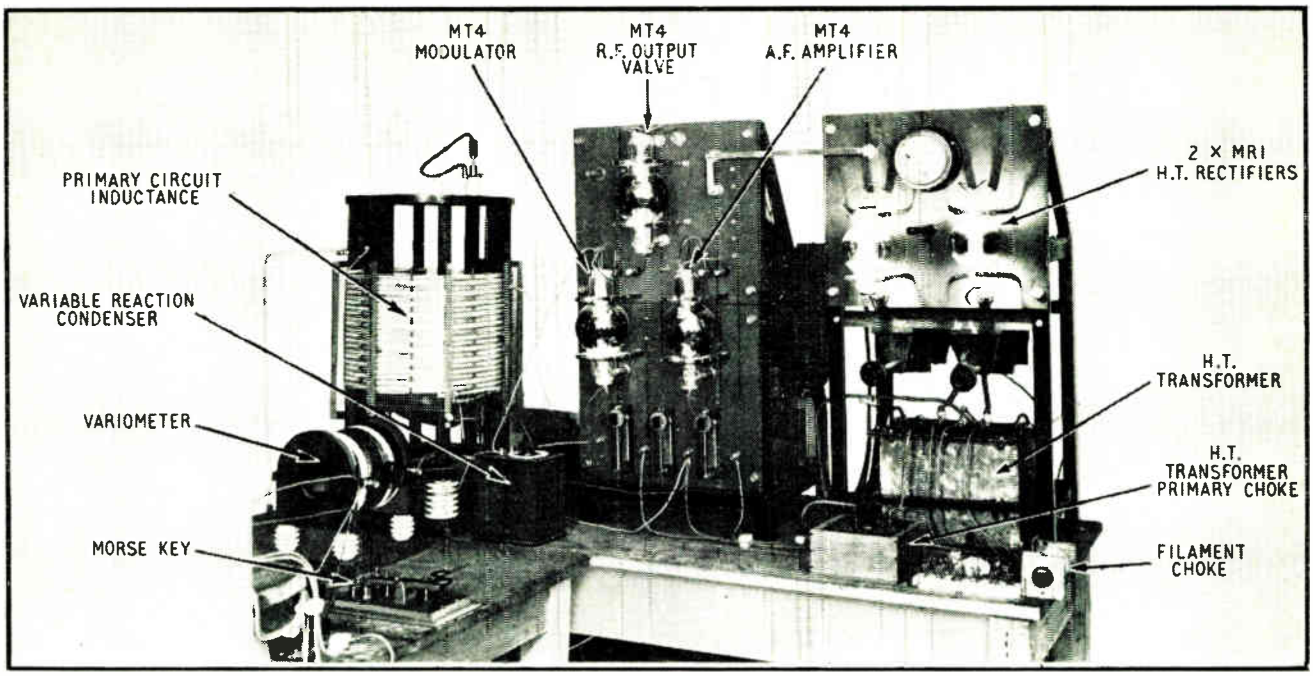
For the first few months, morse was transmitted during a proportion of the programme time for the purpose of providing calibrating signals to amateurs. Keying was effected by interruption of the high-tension transformer primary circuit by a standard Marconi Morse key. This key is shown in the lower left of the photograph.

The valves and other components were mounted on two panels obtained from a disused c.w. transmitter.

The circuitry was precisely similar to that of the ground-station transmitter installed at Croydon Aerodrome in 1920. The transmitter was very simple compared with others under development at Writtle at that time and, initially, it was got going within an hour.

Unfortunately, while the Heising modulation circuit was suitable for high quality reproduction, the only valve avail-





able at the date of commencement of service was the M.T.4 which we realised would not be capable of providing reasonably good quality, even for those days.

After one or two transmissions, a microphone amplifier was used in place of the M.T.4 amplifier and three M.T.4 valves with the grids biased positive were used in an effort to obtain linear working. Unfortunately it was not possible to obtain sufficient dissipation at the anodes of these valves to provide class AB working. In the meantime Messrs. N. Ashbridge and H. L. Kirke were working on the problem and devised the characteristics of suitable valves which were developed by the M.O. Valve Co. These were delivered in a remarkably short time and three were used in parallel, operating in the class A mode.

The limitation was then the Peel Connor carbon microphone which was used throughout the transmissions. Unfortunately no other type of microphone was available until Captain Round produced the Round-Sykes microphone in 1923.

On the 29th May 1922 the wavelength was changed to 400 metres and the transmission of morse calibration signals was abandoned.

The coupled circuit was dismantled and a plain aerial circuit was adopted, using an aerial tuning inductance wound with 81/44-stranded cable. This coil was tightly coupled to a secondary winding, known as the "ratio winding" patented by Eckersley in 1919.

The transmitter circuit remained in this condition until the final transmission on the 17th January 1923.

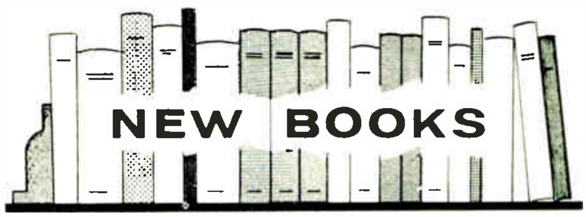
The inductance shown in the photograph is of interest because it was made under Mr. P. P. Eckersley's direction in 1919 and the stranded wire was actually made on the premises. This inductance was also used to investigate the application of Mr. T. L. Eckersley's earth screen to medium-wave aerials.

The components from which the transmitter was built were mainly supplied from our experimental stock in trade. Any suggestion that we were wildly searching for components or struggling to make the transmitter work is simply not correct. If we were short of anything the Marconi Laboratories and Works at New Street, Chelmsford, supplied our wants within the hour.

The physical assembly of the transmitter was carried out by the workshop mechanics, Messrs. F. Bubb and J. Russell.

It is unfortunate that on the cessation of transmission in January 1923 the equipment was dismantled and the parts returned for normal experimental work. All has been lost with the exception of the 6-kW motor generator which the writer found under a tarpaulin in a field at Writtle a few years ago. This he purchased from the Marconi Company, dismantled, dried out and made to work. In due course it will be presented to the Marconi museum.

Engineer-in-Chief, B. N. MacLarty.
Marconi's Wireless Telegraph Co., Ltd.,
Chelmsford.



Electronic Engineering

By Charles L. Alley and Kenneth W. Atwood. Pp. 646 + xxi. John Wiley and Sons Ltd., Gordon House, Greencoat Place, London, S.W.1. Price 79s.

The aim in this book has been to provide a unified treatment of semiconductors and valves in which the circuit analysis is based upon the Laplace transform. The reader is required to have a good foundation of alternating-current circuits, calculus and the Laplace transform.

One unusual effect of this outlook is the dominance of root-locus methods in the treatment of oscillators and negative-feedback amplifiers.

Chapter one covers Electron ballistics, chapter two Semiconductors, chapter three Diodes and chapter four Basic amplifiers, which means transistors and triode valves. After that all the usual things are treated with the aid of equivalent circuits and algebra. For large signals both power series and graphical methods are used.

The root-locus treatment of negative feedback is interesting and is certainly worth careful study. It is a method which offers advantages from the designer's point of view but it is debatable whether it is suitable for the student. In the reviewer's opinion it does not lead to the same physical understanding as the more orthodox methods and he would prefer to see it deferred until the student has gained familiarity with other methods.

Taken as a whole the book is a good one and there is enough originality in the approach to make it more than just another book on electronic engineering.

Metallurgical Principles for Engineers

By J. G. TWEEDDALE, F.I.M., A.M.I.Mech.E., A.M.Inst.W. Pp. 560 + vii. Iliffe Books Ltd., Dorset House, Stamford Street, London, S.E.1. Price 85s.

The relations between metal physics and the practical use of metals are explained and the development of specific properties in alloys is discussed. Considerable stress is laid upon service problems and conditions, including the effect of high stress, temperature, corrosion, fatigue, notch sensitivity, radiation damage and wear. Fabrication methods are also covered.

A New Approach to the Design of Switching Circuits

By H. ALLEN CURTIS. Pp. 635 + viii. D. Van Nostrand Co. Ltd., 358 Kensington High Street, London, W.14. Price 144s.

This book 'is intended as a guide for a one-semester advanced course in switching theory'. That it is not for the beginner is evident from the chapter headings, for only the first two, Fundamentals of Switching Theory and Systematic Methods of Simplifying Switching Networks, will have meaning to the newcomer to the subject. They are followed by chapters on simple and complex disjunctive decompositions and simple nondisjunctive decompositions. After that proper complex decomposition theory is treated and then an algorithm for the best of such decompositions; the last chapter is on The Final Algorithm and its Applications.

The start of the book is simple enough but Boolean algebra starts on p. 18 and the beginner very quickly gets out of his depth. A good general knowledge of the subject and a thorough familiarity with switching algebra are essential prerequisites for using this book.

Instruments for Measurement and Control, 2nd Ed.

By WERNER G. HOLZBOCK. Pp. 391 + vii. Chapman and Hall Ltd., 37 Essex Street, London, W.C.2. Price 80s.

The author has written this book 'to acquaint the reader with the types of instruments available for the measurement and control of process variables; to be a reference book for those who are searching for an instrument that fills their specific needs; to give the man who develops new instruments an opportunity to compare some of the approaches used by his colleagues in the solution of problems common to the instrument industry'.

The first nine chapters are headed:—Temperature, Humidity and moisture, Pressure, Flow, Liquid level, Density, Viscosity, Speed and Analysis. There are then five chapters on controllers, Automatic, Electric, Self-operated, pneumatic and hydraulic, Time function and Final Elements.

The treatment is descriptive and without mathematics and to a large extent it is descriptive of particular commercial instruments of American manufacture. The book should be a useful introduction to those who are unfamiliar with present-day instrument practice and should be readily understood by anyone with a good general knowledge of elementary physics.

Microminiaturization

Edited by G. W. A. DUMMER. Pp. 355 + x. Pergamon Press Ltd., Headlington Hill Hall, Oxford. Price 105s.

Published for and on behalf of the Advisory Group for Aeronautical Research and Development, North Atlantic Treaty Organization, this book contains the Proceedings of the AGARD Conference which was held 24th-26th July 1961 at Oslo. The sections comprise Survey papers, Micromodules, Microcircuits and Solid Circuits. Although mainly in English, a few of the papers included are in French.

Six-Language Dictionary of Automation, Electronics and Scientific Instruments

Compiled by A. F. DORIAN. Pp. 732. Iliffe Books Ltd., Dorset House, Stamford Street, S.E.1. Price 105s.

The languages are English, French, German, Italian, Spanish and Russian. All the English words are arranged in alphabetical order and each word is preceded by an index number. Against each English word, in the same row, appear the same words translated into French, German, Italian, Spanish and Russian. The dictionary itself is followed by five indexes, one for each of these five languages. Thus, if the reader wishes to translate from, for example, German into any one of the other five languages, he refers to the appropriate word in the German index which is followed by a number. He then refers to this number in the dictionary and obtains the corresponding words in the other languages.

The Preface is repeated in all six languages and gives full instructions for the use of this dictionary, which with its 5,500 English phrases and nearly 65,000 foreign equivalents will prove invaluable to all interested in technical developments in automation and electronics.

Electron Transport in Metals

By J. L. OLSEN. Pp. 121 + viii. John Wiley and Sons Ltd., Gordon House, Greencoat Place, London, S.W.1. Price 34s. (cloth), 19s. (paper).

This is an Interscience Tract on Physics and Astronomy and 'is intended as an introduction for experimental physicists to the phenomena connected with conduction in metals'. It does not cover superconductivity. It covers bulk phenomena in zero magnetic field, galvonomagnetic effects, size effects and miscellaneous problems after an initial theoretical summary.

British Canadian Trade Association Register 1962-63 of British Industrial Products for Canada. 10th Ed.

Published jointly by Kelly's Directories Ltd. and Iliffe Books Ltd. (Dorset House, Stamford Street, S.E.1) for the British Canadian Trade Association—Managers of the British Trade Centres in Toronto, Montreal and Vancouver. Pp. 579. Price 15s. (including postage).

The book includes a classified list of products, a French glossary, Canadian distributors' announcements and lists of British manufacturers and distributors, proprietary names and trade marks.

The Pegasus Programming Manual

By G. E. FELTON. Pp. 319. Ferranti Ltd., The London Computer Centre, 68 Newman Street, London, W.1. Price 50s.

This is primarily a handbook on programming for the Ferranti Pegasus 1 and 2 computers, but it has an introductory general chapter on digital computers. Since the page size is 8 in. by 13 in. the book is a lot larger than its 319 pages seems to indicate; it is a reproduction of typescript and is well illustrated.

General Characteristics of Linear Strain Gage Accelerometers Used in Telemetry

By P. S. LEDERER. National Bureau of Standards Technical Note 150. Pp. 57. Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. Price 40 cents.

A General Survey of the Semiconductor Field

By GEORGE WILLIAM REIMHERR. National Bureau of Standards Technical Note 153. Pp. 44. Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. Price 30 cents.

Manufacturers' Literature

Hughes Semiconductors. The 8-page abridged catalogue gives salient information on the principal diodes and transistors from the range produced by:
Hughes International (U.K.) Ltd., Kershaw House, Great West Road, Hounslow, Middlesex.

For further information circle 59 on Service Card

Transistorized Portable Transfer Function Analyser Type 120. In this 8-page leaflet an instrument is described which has been designed to test, without any additional equipment, servo systems of an electronic, electrical and hydraulic nature.
Servo Consultants Ltd., 162 Kensal Road, London, W.10.

For further information circle 60 on Service Card

Secraphone Equipment. An illustrated 4-page leaflet describing the Secraphone S2N telephone privacy equipment produced by:
Telephone Manufacturing Company, Transmission Division, Sevenoaks Way, St. Mary Cray, Orpington, Kent.

For further information circle 61 on Service Card

Keithley Short Form Catalog. Keithley Instruments, U.S.A., have specialized in the development of high-grade d.c. measuring instruments. In this 4-page leaflet their current electrometers, micro-microammeters and microvoltmeters are described. Distributed in the U.K. by:
Livingston Laboratories Ltd., 31 Camden Road, London, N.W.1.

For further information circle 62 on Service Card

Recording Dissolved Oxygen. A 2-page leaflet describing the Kent Mk 3 recorder in association with the Wallace & Tiernan analyser to form a system to record dissolved oxygen.
George Kent Ltd., Luton, Beds., and Wallace & Tiernan Ltd., Power Road, London, W.4.

For further information circle 63 on Service Card

'Minicount' Hengstler Electromagnetic Counters. A range of six-digit general purpose counters, with manual or electrical reset facilities and counting speed ranges of 1,500, 2,400 and 3,000 per minute, is described in this 8-page leaflet. Also described is a range of predetermined counters which count down to zero from a pre-set number.
Lancashire Dynamo Electronic Products Ltd., Rugeley, Staffs.

For further information circle 64 on Service Card

'Variac' Continuously-Adjustable Autotransformers. The current range of the General Radio 'Variacs' (over 200 different models) is described in detail in this 28-page booklet. Complete specifications are given along with prices for the American and Canadian markets.
General Radio Company, West Concord, Massachusetts, U.S.A.

For further information circle 65 on Service Card

Brush Silicon Planar Epitaxial Transistors. Brush Crystal have produced six separate leaflets which together give full details of a family of 16 n.p.n. silicon planar epitaxial transistors.
Brush Crystal Co. Ltd., Hythe, Southampton.

For further information circle 66 on Service Card

AMP Pin and Socket MDM Connectors. An 8-page illustrated brochure which gives details of the 'AMPin-cert' MDM range of pin and socket connectors; this range features snap-in multi-way contacts with any combination of connections up to 104.
Aircraft-Marine Products (Great Britain) Ltd., Amplo House, Saffron Hill, London, E.C.1.

For further information circle 67 on Service Card

R.C.A. Semiconductor Product Guide. Details are given in this 12-page brochure of the current R.C.A. range of transistors, tunnel diodes, multiple diodes and rectifiers for industrial, military and domestic applications.
Radio Corporation of America, Semiconductor and Materials Division, Somerville, N.J., U.S.A.

For further information circle 68 on Service Card

Economical Rapid Accurate Reliable Analysis. In this 8-page brochure a range of instruments for the automatic analysis of materials is described.
Hilger and Watts Ltd., 98 St. Pancras Way, London, N.W.1.

For further information circle 69 on Service Card

Panax Nuclear Instrumentation: Price List. This 12-page brochure gives brief details and prices for the Panax range of nucleonics instruments for industrial, medical, educational and research applications.
Panax Equipment Ltd., Holmethorpe Industrial Estate, Redhill, Surrey.

For further information circle 70 on Service Card

Synchro and Resolver Test Sets. This 24-page catalogue gives details of the current range of test equipment for synchros and resolvers which is manufactured by:
Theta Instrument Corp., 520 Victor Street, Saddle Brook, New Jersey, U.S.A.

For further information circle 71 on Service Card

Ferranti Classified Index of Computer Literature, Library Services and Films. This 20-page publication is issued to provide information about the Ferranti computer literature and services which are currently available.
Ferranti Ltd., 68 Newman Street, London, W.E.

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Industrial Electronic Converters. The unit described in this 12-page brochure transforms the basic measurements of process variables (e.g. temperature, pressure, flow) into accurate proportional 0 to 10 mA d.c. signals.
George Kent Ltd., Luton, Bedfordshire.

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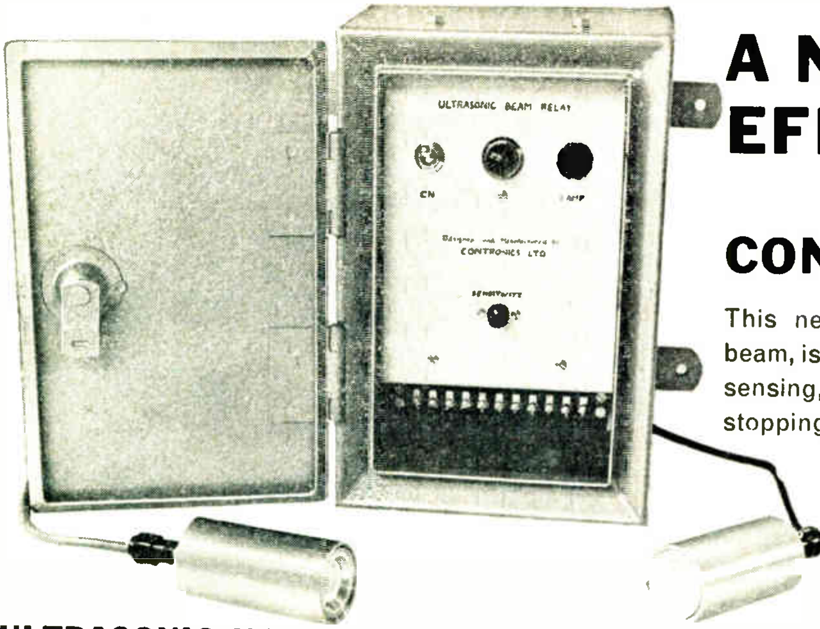

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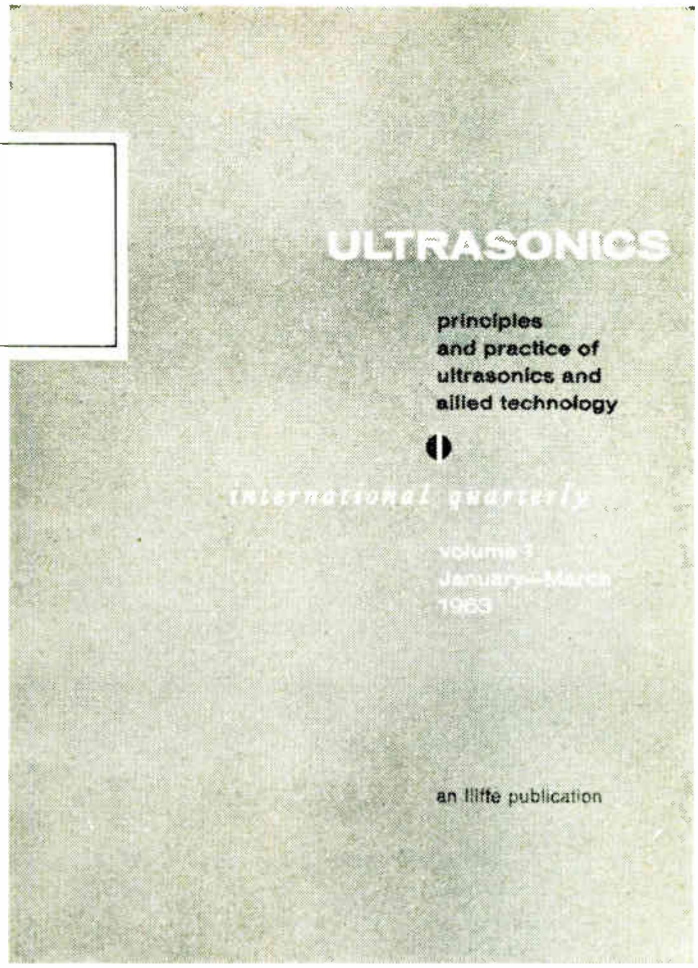

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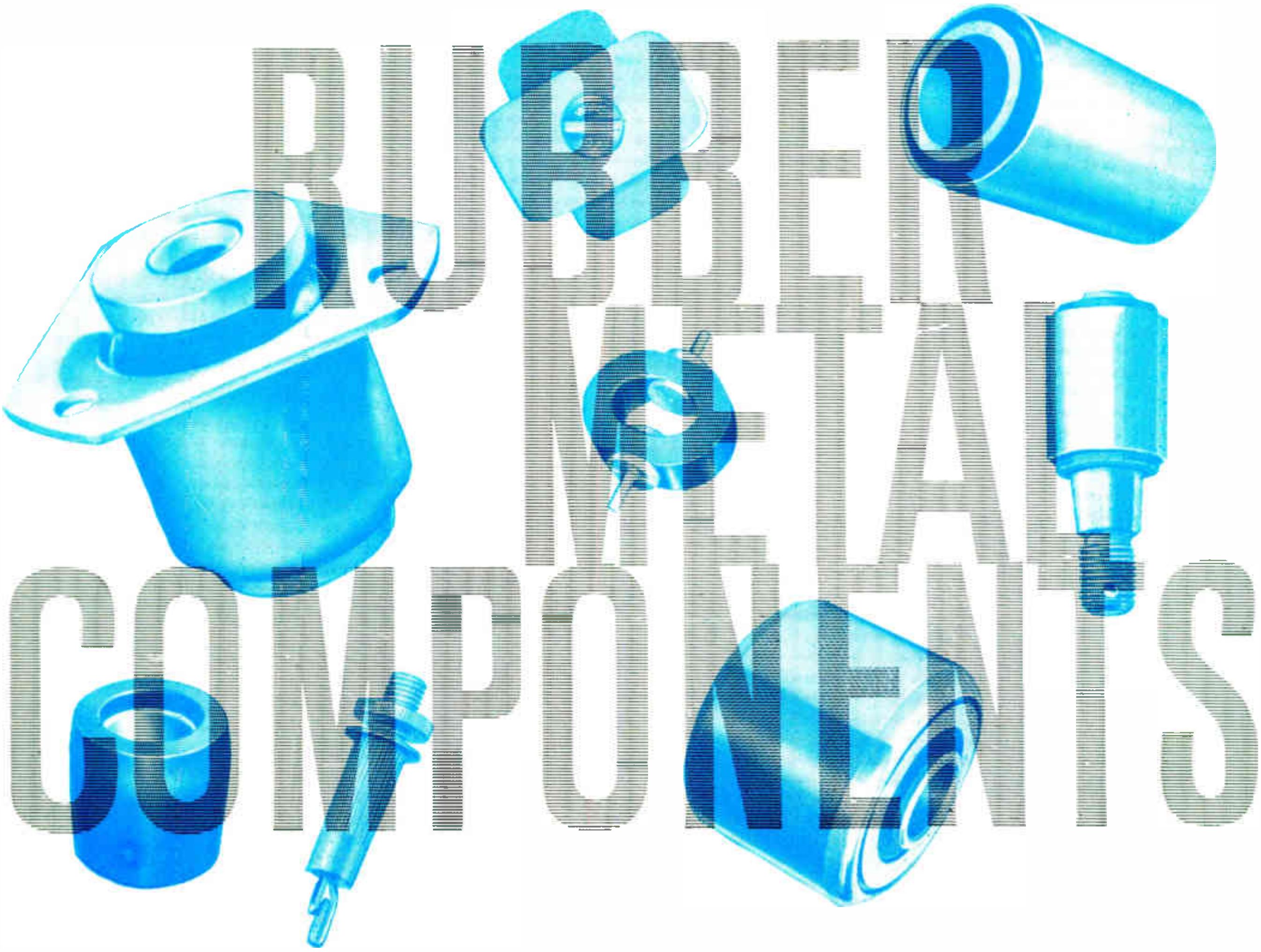

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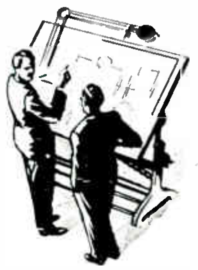

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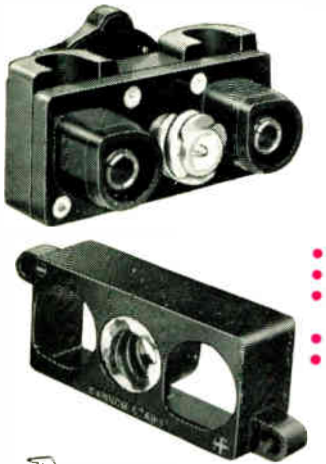

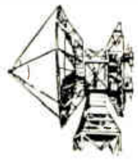

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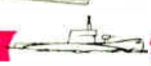
- Positive polarisation

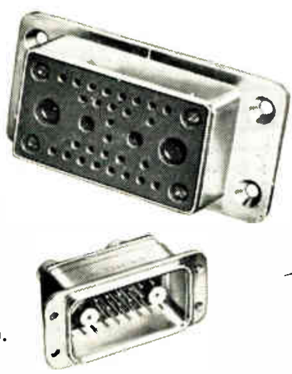
Write for Power Catalogue.



DPA/DPD CONNECTORS

- Non-sealed lightweight multi-pole connectors for rack/panel applications.
- Melamine insulators.
- Gold plated copper contacts.
- Various layouts available, including coaxial and high voltage combinations.
- Maximum number of contacts: 32 poles in DPA connectors, 112 poles in DPD connectors.
- Various current carrying capacities and voltage ratings.

Write for HMC Catalogue (DPA Connectors) DP-12 Catalogue (DPD Connectors).



TYPICAL EXAMPLES OF
CANNON
CONNECTORS
MADE IN
GREAT BRITAIN

One tends to associate the symbol CANNON PLUGS with electrical connectors manufactured in the U.S.A., but in actual fact, over 60 per cent of the Cannon connectors sold in Great Britain are manufactured entirely at the Cannon factory in London.

The facilities of Cannon Electric (Great Britain) Limited, include:

connector research, development, design and engineering; a fully equipped test laboratory; machine and model shops; toolroom; injection and compression moulding machines; quality control and inspection, etc.

All the divisions of the Company are manned by highly competent, qualified personnel with many years background of technological "know-how". The Sales and Engineering Departments provide a Technical Service of the highest calibre and the Company will gladly undertake development contract work.

Cannon Electric (Great Britain) augments and supplements the activities of the parent company factories in the U.S.A., and contributes in no small way in helping to maintain the name CANNON as the world's foremost manufacturer of electrical connectors.

CANNON PLUGS®

CANNON ELECTRIC

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