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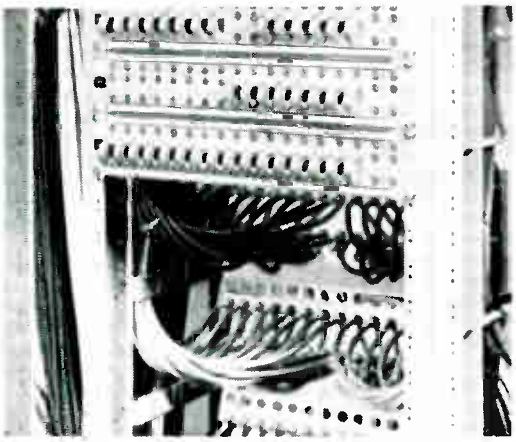

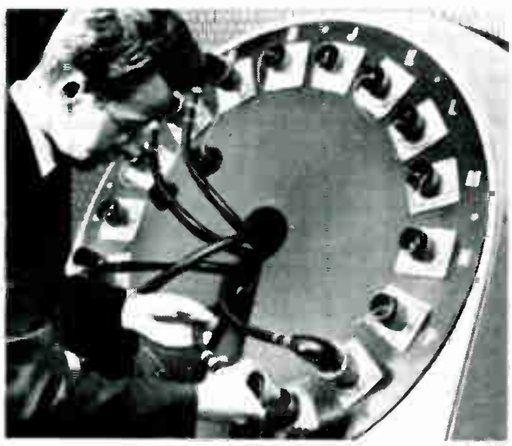

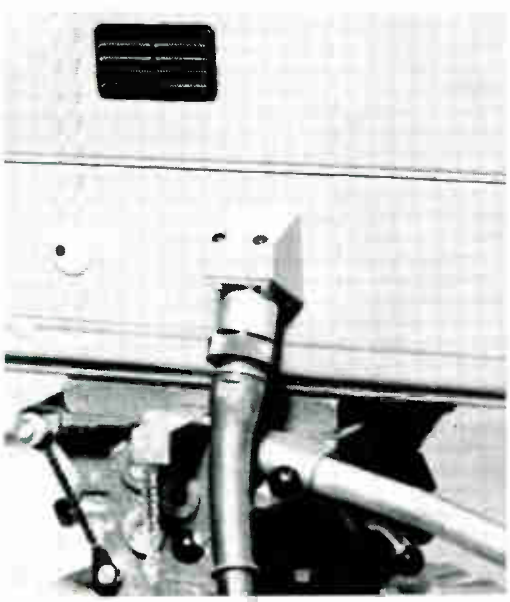

# Abstracts and References

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

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



## ACOUSTICS AND AUDIO FREQUENCIES

534.14-8: 537.311.33 **3217**

**Ultrasonic Amplification in Semimetals.**—W. P. Dumke & R. R. Haering. (*Phys. Rev.*, 15th June 1962, Vol. 126, No. 6, pp. 1974–1977.) An effect similar to that observed in CdS [1 of January (Hutson et al.)] is described for semimetals; in this case amplification is obtained with much lower current densities.

534.2 + 538.566 **3218**

**Propagation of Spherical Waves in Thin Plates and Narrow Slits.**—Ott. (See 3304.)

534.2-14: 534.88 **3219**

**Shallow-Water Transmission.**—H. W. Marsh & M. Schulkin. (*J. acoust. Soc. Amer.*, June 1962, Vol. 34, No. 6, pp. 863–864.) "Expressions and tables are presented for computing the shallow-water transmission loss as a function of bottom type, sea state, frequency, water depth, and range. A table of probable errors is also presented as a function of frequency and range."

534.2-8-14 **3220**

**Investigation of the Scattering of Sound by Bubbles Generated by an Artificial Wind in Sea Water and the Statistical Distribution of Bubble Sizes.**—V. P. Glotov, P. A. Kolobaev & G. G. Neuimin. (*Akust. Zh.*, 1961, Vol. 7, No. 4, pp. 421–427.) The frequency dependence of the scattering is investigated in the range 20–100 kc/s.

534.213.4 **3221**

**The Effect of Motion of the Medium on Sound Propagation in a Waveguide with Cavity Resonators in the Walls.**—A. D. Lapin. (*Akust. Zh.*, 1961, Vol. 7, No. 4, pp. 446–449.) A generalization of the results of previous work (*ibid.*, 1961, Vol. 7, No. 2, pp. 218–223).

534.213.4 **3222**

**Irregular Acoustic Waveguides.**—V. V. Shevchenko. (*Akust. Zh.*, 1961, Vol. 7, No. 4, pp. 484–491.) Equations are derived based on cross-section eigenfunctions of uniform acoustic waveguides. An approximate solution is given for a slightly irregular waveguide.

534.232-8-14 **3223**

**Generation and Detection of Ultra-High-Frequency Sound in Liquids.**—F. Dunn & J. E. Breyer. (*J. acoust. Soc. Amer.*, June 1962, Vol. 34, No. 6, pp. 775–778.) Two methods of using piezoelectric plates to produce acoustic waves in liquid in the Gc/s range are described. The thermoelectric method of detecting acoustic energy in liquids is briefly discussed. Data obtained by these techniques are presented.

534.283-8: 537.227: 547.476.3 **3224**

**The Absorption of Ultrasound in Rochelle Salt near Curie Point.**—L. G. Merkulov & E. S. Sokolova. (*Akust. Zh.*, 1961, Vol. 7, No. 4, pp. 495–496.) An increase of absorption near the Curie point is observed for longitudinal waves. Results are shown graphically.

534.283.2: 534.88 **3225**

**Sound Absorption in Sea Water.**—M. Schulkin & H. W. Marsh. (*J. acoust. Soc. Amer.*, June 1962, Vol. 34, No. 6, pp. 864–865.) "An expression is presented for sound absorption in sea water as a function of frequency, temperature, salinity, and pressure. It is based on available data reported in the literature and new data taken in the North Atlantic Ocean in the frequency range 2–25 kc/s."

534.283.2-14: 534.88 **3226**

**Acoustic Attenuation in a Liquid Layer over a 'Slow' Viscoelastic Solid.**—A. O. Williams, Jr, & R. K. Eby. (*J. acoust. Soc. Amer.*, June 1962, Vol. 34, No. 6, pp. 836–843.) Bottom material such as well-compacted sand should display absorption of compressional and transverse waves. An analysis of the effects of such material on a liquid-borne signal is developed.

534.76 **3227**

**On the Directional Localization of Sound in the Stereophonic Sound Field.**—Y. Makita. (*E.B.U. Rev.*, June 1962, No. 73A, pp. 102–108.) The direction of propagation of the wave front in a two-channel stereophonic sound field is investigated as a function of studio and listening-room conditions. Wave-front anomalies are discussed and a comparison is made between theoretical and experimental values.

534.8-8: 538.567 **3228**

**Some Applications of an Ultrasonic Light Modulator.**—W. Liben. (*J. acoust. Soc. Amer.*, June 1962, Vol. 34, No. 6, pp. 860–861.) The device has been used as a frequency analyser for electrical signals and for the production of a set of uniformly spaced optical markers. The design formula for the optical system and the ultrasonic resolution are given.

534.84.072 **3229**

**Recent Results of Model Tests of Room Acoustics.**—E. Krauth & R. Bücklein. (*Frequenz*, June 1962, Vol. 16, No. 6, pp. 226–229.) Report on objective and subjective measurements of reverberation time, sound level and diffusion in a 1:10 scale model of an auditorium.

621.395.61+621.395.623.7 **3230**

**The Design of Electroacoustic Transducers with the Aid of Analogue, Purely Electrical Networks.**—E. Martin. (*Frequenz*, June 1962, Vol. 16, No. 6, pp. 208–215.) Equivalent circuits are derived for electroacoustic transducers, on the basis of electrical analogues for mechanical and acoustic vibrating systems.

621.395.623.73 **3231**

**'Orthophase' Loudspeaker.**—(*Elektronische Rundschau*, May 1962, Vol. 16, No. 5, pp. 226–228.) Brief description of a French electrodynamic loudspeaker system built up of individual cells in which the diaphragm is a plane sheet of very light plastic. Performance data and details of the associated transistor output amplifier are also given.

621.395.625.3 **3232**

**A Multichannel Transmission System with Increased Signal/Noise Ratio.**—P. Scherer. (*Elektronische Rundschau*, Feb. 1962, Vol. 16, No. 2, pp. 51–53.) A multitrack tape recording method is described which, with the aid of a mixing process, makes better use of the storage capacity of each track.

## AERIALS AND TRANSMISSION LINES

621.372.2 : 621.315.212 **3233**

**The Attenuation of Line Circuits.**—H. Hein. (*Frequenz*, June 1962, Vol. 16, No. 6, pp. 223–225.) Calculations are made of the attenuation of $\lambda/4$ and $\lambda/2$ capacitively loaded line sections, and of a coaxial line with inner and outer conductors of different material.

621.372.22 **3234**

**Inhomogeneous Transmission Lines with Nonuniform Loss Angle of the Shunt Admittance per Unit Length.**—W. Jutzi. (*Z. angew. Phys.*, March 1962, Vol. 14, No. 3, pp. 138–152.) Further application of Klopfenstein's design principles to lossy lines. See also 1450 of May.

621.372.8 : 621.396.44 **3235**

**System Aspects of Long-Distance Communication by Waveguide.**—A. E. Karbowiak. (*Proc. Instn elect. Engrs*, Part B, July 1962, Vol. 109, No. 46, pp. 336–344.) In assessing a system, the attenuation of the waveguide, its dispersion characteristic and mode conversion-reconversion phenomena only need be considered. A simplified theory is proposed and the advantages of pulse modulation systems are discussed.

621.372.821 **3236**

**On the Diffraction of a Pulse at the Open End of a Parallel-Plate Waveguide.**—R. C. T. da Costa. (*Nuovo Cim.*, 1st July 1962, Vol. 25, No. 1, pp. 55–68.) An analysis by a Fourier method of the distortion of pulse shape produced by energy accumulation at the open end of the guide.

621.372.831 **3237**

**A New Design of Low-V.S.W.R. Waveguide Taper Transition.**—M. A. R. Gunston & J. K. Skwirzynski. (*Marconi Rev.*, 2nd Quarter 1962, Vol. 25, No. 145, pp. 108–119.) The necessary constructional data for a given rectangular-waveguide taper have been programmed for the Deuce computer. A simple design procedure is given and the various assumptions made are discussed.

621.372.832.6 **3238**

**Some Design Aspects of Components utilizing Symmetric 3-db Hybrids.**—R. J. Mohr. (*Microwave J.*, June 1962, Vol. 5, No. 6, pp. 90–94.) The basic requirements are given for hybrid junctions used in phase-shifters, switches, diplexers and power dividers.

621.372.852.1+621.372.832.1 **3239**

**Waveguide Frequency-Separating Network.**—P. Ponwitz. (*Tech. Mitt. RFZ, Berlin*, June 1962, Vol. 6, No. 2, pp. 77–80.) The system described consists of two band-pass filters connected to a T-junction. The frequencies separated are 3 600 and 3 813 Mc/s.

621.372.852.2 : 621.382.23 **3240**

**A Very Fast, Voltage-Controlled Microwave Phase Shifter.**—H. N. Dawirs & W. G. Swarner. (*Microwave J.*, June 1962, Vol. 5, No. 6, pp. 99–107.) The phase shifter, which consists of varactor diodes shunted at intervals across a transmission line, is analysed in detail.

621.372.852.22 : 621.318.134 **3241**

**Wave Propagation along a Longitudinally Magnetized Ferrite Rod in an Electrically Anisotropic Ambient.**—E. Neckenbürger. (*Z. angew. Phys.*, May 1962, Vol. 14, No. 5, pp. 282–288.) The ferrite rod considered is placed along the axis of a rectangular waveguide. The theoretical and experimental investigations discussed deal with polarization changes and field distribution effects along this rod. Practical applications mentioned include an amplitude modulator and microwave switch and phase shifters.

621.396.67.095.3 **3242**

**The Plotting of Radiation Patterns of Metre-Wave Transmitter Aerials with the Aid of a Helicopter.**—E. Marti. (*Tech. Mitt. PTT*, June 1962, Vol. 40, No. 6, pp. 189–198. In German and French.) Methods of measuring horizontal and vertical field-strength distribution for transmitter aerials installed in difficult terrain are briefly reviewed. The procedure and apparatus used for measurements by helicopter are described, and results obtained for transmitters operating at 67·75 and 229·75 Mc/s are given.

621.396.674.1 **3243**

**Radiation Field of the Corner-Driven Square-Loop Antenna.**—S. Prasad. (*Proc. nat. Inst. Sci. India*, A, 26th Jan. 1962, Vol. 28, No. 1, pp. 120–131.) The radiation properties of the square loop driven in the zeroth phase sequence, the second phase sequence and a simple superposition of the two phase sequences are studied.

621.396.676.012.12 **3244**

**Antenna Pattern for Point Reflectors on the Spherical Earth.**—D. Levine. (*J. Franklin Inst.*, April 1962, Vol. 273, No. 4, pp. 265–275.) The design of airborne aerial arrays to give constant return over a spherical earth, as opposed to a plane surface, is considered. Earth-curvature correction is significant if the maximum radar range exceeds $R_M/4$ where $R_M$ is the distance to the radio horizon. See also 3640 of 1961.

621.396.677.3 : 621.396.965 **3245**

**Some Mutual Impedance Effects in Phased Array.**—L. Parad. (*Microwave J.*, June 1962, Vol. 5, No. 6, pp. 87–89.) The source pattern of the array indicates mismatch effects looking into an element as the array pattern is steered. Thus a design procedure may be based on the desired source pattern and mutual coupling effects need not be measured directly.

621.396.677.71 **3246**

**Theory of Waveguide Slot Radiators with Any Aperture.**—P. Navé. (*Z. angew. Phys.*, May 1962, Vol. 14, No. 5, pp. 277–281.) The effect on internal wave propagation of an aperture of any shape in the wall of a circular waveguide is investigated for the $H_{11}$ mode of incident field.

621.396.677.83 : 621.396.43 : 551.507.362.2 **3247**

**The 85-ft Steerable Dish Aerial at Goonhilly Downs.**—H. C. Husband. (*Brit. Commun. Electronics*, Aug. 1962, Vol. 9, No. 8, pp. 584–586.) An 85-ft paraboloidal dish aerial designed for frequencies up to at least 6 Gc/s is described. Automatic directional control is provided by punched tape; manual beam swinging of 1° is possible by movement of the aerial feed.

## AUTOMATIC COMPUTERS

681.142 **3248**

**Computer Memories—Possible Future Developments.**—J. A. Rajchman. (*RCA Rev.*, June 1962, Vol. 23, No. 2, pp. 137–151.)

681.142 : 539.23 **3249**

**A Woven Memory Matrix with Cylindrical Electroplated Film Elements.**—D. F. A. MacLachlan. (*Brit. Commun. Electronics*, Aug. 1962, Vol. 9, No. 8, pp. 602–604.) The matrix has higher outputs and better read-out characteristics than have planar films.

681.142 : 621.318.042.1 **3250**

**Novel Digital Signal Generator uses Magnetic-Core Pegboard.**—Way Dong Woo. (*Electronics*, 6th July 1962, Vol. 35, No. 27, pp. 46–49.) "Miniature permanent magnets are inserted in removable plastic boards to set up a desired program rapidly and economically for digital pattern generation."

681.142 : 621.395.625.3 **3251**

**Maximum Pulse-Packing Densities on Magnetic Tape.**—G. C. Ziman. (*Electronic Engng*, Aug. 1962, Vol. 34, No. 414, pp. 521–525.) Factors contributing to interchannel time-displacement errors on digital-tape handlers are considered. A formula is derived for the character-transfer rate corresponding to the maximum pulse-packing density for parallel-track systems in current use.

## CIRCUITS AND CIRCUIT ELEMENTS

621.3.004.6 **3252**

**The Determination of the Reliability and Life of Electrical Circuit Components.**—H. Wilde. (*Arch. tech. Messen*, May & June 1962, Nos. 316 & 317, pp. 115–118 & 139–142.) Accelerated life tests and the analysis of results are discussed with reference to data on actual failure rates.

621.3.019.3 **3253**

**The Reliability of Installations using Stand-By Components with Exponential Distribution of Component Lifetimes.**—H. Störmer. (*Arch. elekt. Übertragung*, July 1962, Vol. 16, No. 7, pp. 317–327.) The relation between the reliability of the components and the reliability of the system is investigated. The greatest increase in reliability is obtained if each component is supplemented by one or more stand-by components. The time of the first system failure can be determined from the failure rate of the components.

621.316.86.004.6 **3254**

**Investigations regarding the Life and Reliability of Carbon-Film Resistors.**—H. Forster. (*Nachrichtentech. Z.*, May 1962, Vol. 15, No. 5, pp. 220–222.) Difficulties in applying the normal criteria of reliability and failure rate to carbon-film resistors are discussed with reference to test results.

621.318.57 : 621.382.23 : 681.142 **3255**

**Fluctuations in Bistable Tunnel-Diode Circuits.**—R. Landauer. (*J. appl. Phys.*, July 1962, Vol. 33, No. 7, pp. 2209–2216.) Following on earlier work on computing devices (e.g. *IBM J. Res. Develop.*, July 1961, Vol. 5, No. 3, pp. 183–191) the activated jump between two dissipative states is analysed. An idealized physical model is used to find which of the states is the preferred one.

621.372.44 : 621.318.57 **3256**

**Composite Characteristics of Negative-Resistance Devices and their Application in Digital Circuits.**—C. A. Renton & B. Rabinovici. (*Proc. Inst. Radio Engrs*, July 1962, Vol. 50, No. 7, pp. 1648–1656.) By interconnecting several two-terminal negative-resistance devices, multistable *I*/*V* characteristics suitable for digital circuits can be obtained. A modified transistor flip-flop circuit is described.

621.372.5 **3257**

**The Realization of Differentiating Circuits with Passive Circuit Elements.**—G. Schweizer. (*Elektronische Rundschau*, Feb. 1962, Vol. 16, No. 2, pp. 65–67.)

621.372.5 : 621.391.822 **3258**

**Noise Figure and Network Representation of Noisy Linear Two-Ports.**—D. A. Linden. (*J. Franklin Inst.*, April 1962, Vol. 273, No. 4, pp. 276–282.)

621.372.512 **3259**

**Quadripoles for Impedance Transformation with Minimum Attenuation.**—W. Hassenpflug & H. R. Heller. (*Elektronische Rundschau*, June 1962, Vol. 16, No. 6, pp. 261–262.) Formulae giving impedance and attenuation of frequency-independent matching quadripoles are derived.

621.372.54 **3260**

**The Use of Crystals in Networks Designed on the Basis of the Insertion-Loss Theory.**—W. Haas. (*Frequenz*, May 1962, Vol. 16, No. 5, pp. 161–167.) The synthesis of sharp cut-off filters incorporating piezoelectric resonators is discussed and examples are given.

621.372.54 : 534.1 **3261**

**The Transformation of Coupling in Mechanical Filters with Flexural Resonators Free to Vibrate on Both Sides.**—M. Börner. (*Arch. elekt. Übertragung*, July 1962, Vol. 16, No. 7, pp. 355–358.) See also 4030 of 1961.

621.372.54 : 621.374 **3262**

**An Energy Criterion for the Assessment of Pulse Filters.**—W. Postl. (*Arch. elekt. Übertragung*, July 1962, Vol. 16, No. 7, pp. 351–355.) A criterion based on the energy distribution of a single pulse, which is more generally applicable than the criterion given by Hermann & Schüssler (1751 of 1961), is defined. The performance of pulse-shaping networks and optimum pulse shapes for carrier-frequency telegraphy systems are discussed.

621.372.553 **3263**

**A Possibility of Forming Almost Ideal All-Pass Networks by Additions to Lossy Bridged-T Sections.**—P. Birgels. (*Nachrichtentech. Z.*, May 1962, Vol. 15, No. 5, pp. 205–212.) A circuit is derived for the equalization of amplitude distortion due to losses (see 2916 of September). Limiting conditions for the circuit elements are stated.

621.372.57 : 621.382.3 **3264**

**Characteristic Matrices of the Basic Transistor Circuits.**—G. Marte. (*Arch. elekt. Übertragung*, July 1962, Vol. 16, No. 7, pp. 343–346.) The characteristic matrices and equivalent circuits of active quadripoles (2917 of September) are calculated for the three basic transistor-circuit configurations. The cascade connection of two quadripoles is also considered.

621.372.6 **3265**

**On the Sign Pattern of Network Matrices.**—D. P. Brown & M. B. Reed. (*J. Franklin Inst.*, March 1962, Vol. 273, No. 3, pp. 179–186.) A complete description of the sign pattern and the chord (mesh) and the branch (node-pair) matrices corresponding to connected graphs is developed insofar as this sign pattern depends only on elements of the graph and not on possible synthesis techniques.

621.372.6 **3266**

**A Review of Orthogonal Square-Wave Functions and their Application to Linear Networks.**—J. L. Hammond, Jr, & R. S. Johnson. (*J. Franklin Inst.*, March 1962, Vol. 273, No. 3, pp. 211–225.) The properties of Haar and Walsh functions are summarized and equations are derived which give the output of linear networks in terms of these functions.

621.373.421.13 **3267**

**Phase-Stable Oscillators for Space Communications, including the Relationship between the Phase Noise, the Spectrum, the Short-Term Stability, and the *Q* of the Oscillator.**—L. R. Malling. (*Proc. Inst. Radio Engrs*, July 1962, Vol. 50, No. 7, pp. 1656–1664.) Methods of observing and measuring phase instability in crystal oscillators are discussed and a simple theory is proposed which explains phase noise in terms of established laws of thermal agitation.

621.373.431 **3268**

**A Two-State Device with Two Inductively Coupled Colpitts Oscillators.**—B. R. Nag. (*J. Brit. Instn Radio Engrs*, July 1962, Vol. 24, No. 1, pp. 45–52.) A mathematical analysis of a system is given with details of an experimental model. It can be operated as a two-state device in which the resolving time is better than that of conventional circuits.

621.374 **3269**

**High-Current Pulse Shaping using S.C.R. and Delay Lines.**—E. Dell'Oro. (*Electronic Engng*, Aug. 1962, Vol. 34, No. 414, pp. 557–559.)

621.374.4 : 621.382.23 **3270**

**Frequency Multipliers using Tunnel Diodes.**—H. Graf. (*Nachrichtentech. Z.*, May 1962, Vol. 15, No. 5, pp. 213–219.) An approximation function is derived for the tunnel-diode characteristic and used to investigate the performance of single-stage frequency doublers. Cascade-connected doubler stages are also discussed.

621.374.5 **3271**

**General Considerations on the Design of Pulse Delay Networks.**—K. H. Hosking. (*Marconi Rev.*, 2nd Quarter 1962, Vol. 25, No. 145, pp. 120–138.) The departure from an ideal network can be reduced to a minimum by increasing the number of components. Three designs are compared, one of which is readily adaptable to r.f. pulses.

621.375.1 : 621.391.822 3272

**The Fundamental Noise Limit of Linear Amplifiers.**—H. Heffner. (*Proc. Inst. Radio Engrs*, July 1962, Vol. 50, No. 7, pp. 1604–1608.) From theoretical considerations, based on Heisenberg's uncertainty principle it is proved that it is impossible to construct a noiseless linear amplifier. An expression for the minimum noise figure is derived and discussed.

621.375.2 : 621.391.822.2 : 536.53 3273

**The Accurate Measurement of Absolute Temperature from Thermal Noise.**—L. Storm. (*Z. angew. Phys.*, March 1962, Vol. 14, No. 3, pp. 117–121.) Theoretical analysis of two methods for determining the absolute temperature from a measurement of thermal noise of a resistance. Optimum design and accuracy limits are discussed.

621.375.4 3274

**Common-Base Amplifier.**—R. Leek. (*Electronic Technol.*, Aug. 1962, Vol. 39, No. 8, pp. 302–306.) The relation between frequency, voltage gain and bandwidth in a common-base amplifier is examined using a simple equivalent circuit. The maximum gain-bandwidth product is always obtained by making the base feedback resistance zero.

621.375.9 : 538.569.4 3275

**High-Resolution Ammonia ($N^{14}H_3$) Maser.**—F. Holuj, H. Daams & S. N. Kalra. (*J. appl. Phys.*, July 1962, Vol. 33, No. 7, pp. 2370–2372.) A single component of the 3,3 inversion line of $N^{14}H_3$ can be isolated by this maser based on Ramsey's principle of separated oscillatory fields.

621.375.9 : 538.569.4 3276

**Construction of a Ruby Maser using Cross-Relaxation Pumping.**—R. Buisson, R. Chicault, D. Descamps, J. Galland & M. Soutif. (*C. R. Acad. Sci., Paris*, 10th April 1961, Vol. 252, No. 15, pp. 2197–2199.) Operating conditions are studied and performance data given.

621.375.9 : 538.569.4 3277

**The Solid-State Maser in Satellite Communication Systems.**—J. C. Walling & F. W. Smith. (*Brit. Commun. Electronics*, Aug. 1962, Vol. 9, No. 8, pp. 596–598.) A description of the characteristics and operating conditions of the maser designed for projects Telstar and Relay.

621.375.9 : 538.569.4 3278

**Negative *L* and *C* in Solid-State Masers.**—R. L. Khyl, R. A. McFarlane & M. W. P. Strandberg. (*Proc. Inst. Radio Engrs*, July 1962, Vol. 50, No. 7, pp. 1608–1623.) The negative resistance of a maser material has a reactive component associated with it. A reactance compensation system is described which considerably improves the gain-bandwidth performance of a cavity maser.

621.375.9 : 538.569.4 3279

**Maser Operation at 96 kMc/s with Pump at 65 kMc/s.**—W. E. Hughes. (*Proc. Inst. Radio Engrs*, July 1962, Vol. 50, No. 7, p. 1691.) Details of construction with a note on a computer method of obtaining suitable energy-level arrangements.

621.375.9 : 538.569.4 3280

**Tunable Millimetre Travelling-Wave Maser Operation.**—F. Arams & B. Peyton. (*Proc. Inst. Radio Engrs*, July 1962, Vol. 50, No. 7, pp. 1697–1698.) Stable operation has been achieved over very large tuning ranges in the $K_a$ band using $Cr^{3+}$-doped $TiO_2$ as the active material.

621.375.9 : 621.372.44 3281

**The 'Negative Conductance' of Parametric Amplifiers.**—G. Schilling. (*Frequenz*, May 1962, Vol. 16, No. 5, pp. 171–176.) The frequency dependence of the negative input conductance is investigated theoretically for a parametric amplifier with parallel-tuned circuits. Experimental results are in good agreement with calculated values.

621.375.9 : 621.382.23 3282

**Tunnel Diode Amplifiers.**—J. O. Scanlan. (*Electronic Technol.*, Aug. 1962, Vol. 39, No. 8, pp. 321–324.) Experimental verification of principles governing the u.h.f. performance of tunnel-diode amplifiers as established in a previous article (*ibid.*, July 1962, Vol. 39, No. 7, pp. 269–276).

621.375.9 : 621.382.23 3283

**Experiments on a Quarter-Wave-Coupled Three-Esaki-Diodes Microwave Amplifier.**—Y. Suematsu & T. Muratani. (*Proc. Inst. Radio Engrs*, July 1962, Vol. 50, No. 7, p. 1696.)

621.376.32 3284

**Frequency Modulation of an *RC* Oscillator.**—J. B. Izatt. (*Electronic Technol.*, Aug. 1962, Vol. 39, No. 8, pp. 316–320.) An *RC* oscillator comprising a chain of cathode followers and a single amplifying stage is capable of producing frequency-modulated waves with wide deviation. A practical model is described with a peak deviation of 200 kc/s on a 5-Mc/s carrier and $< 0 \cdot 3\%$ harmonic distortion.

## GENERAL PHYSICS

537.311.3 3285

**Theory of Transient Space-Charge-Limited Currents in Solids in the Presence of Trapping.**—A. Many & G. Rakavy. (*Phys. Rev.*, 15th June 1962, Vol. 126, No. 6, pp. 1980–1988.) With a number of simplifying assumptions, solutions are derived for the time-dependent current and space-charge distribution following the onset of injection.

537.311.33 3286

**The Theory of Impurity Conduction.**—N. F. Mott & W. D. Twose. (*Advances Phys.*, April 1961, Vol. 10, No. 38, pp. 107–163.) An electron occupying an isolated donor has a wave function localized about the impurity and an energy slightly below the conduction band minimum. Because there is a small but finite overlap of the wave function of an electron on one donor with neighbouring donors, a conduction process is possible in certain circumstances.

537.311.5 : 621.372.2 3287

**Diffusion of Electricity.**—W. H. B. Cooper. (*Electronic Technol.*, July & Aug. 1962, Vol. 39, Nos. 7 & 8, pp. 279–285 & 297–301.) A treatment of the distribution of e.m. fields in a strip conductor based on equivalent circuits and transmission-line theory.

537.312.62 3288

**Theory of Superconductivity: Part 1—Electron-Lattice Interaction.**—R. K. Nesbet. (*Phys. Rev.*, 15th June 1962, Vol. 126, No. 6, pp. 2014–2020.) The interaction responsible for electrical resistivity in perfect metallic crystals is shown to be a form of Jahn-Teller effect.

537.312.8 3289

**Maximum Variational Principle for Conduction Problems in a Magnetic Field and the Theory of Magnon Drag.**—M. Bailyn. (*Phys. Rev.*, 15th June 1962, Vol. 126, No. 6, pp. 2040–2054.)

537.525 : 621.391.822.3 3290

**Elementary Treatment of the Shot Effect and the Noise of a Gas Discharge.**—F. Lüdi. (*Helv. phys. Acta*, 1st June 1962, Vol. 35, No. 3, pp. 220–228. In German.) Schottky's treatment of statistical processes is applied to the problem of noise in plasma, for both dense and rarefied gases.

537.56 3291

**Plasma Source for High Vacuum.**—B. P. Kononov & K. A. Sarksyan. (*Zh. tekh. Fiz.*, Nov. 1961, Vol. 31, No. 11, pp. 1294–1297.) Description of an experimental installation for obtaining plasma by mixing electron and ion beams in a vacuum system with a pressure gradient.

537.56 3292

**Plasma Oscillations with Amplitude-Dependent Frequencies.**—L. Gold. (*J. Electronics Control*, June 1962, Vol. 12, No. 6, pp. 505–506.) Amer's theory (88 of 1959) provides a more accurate picture of plasma oscillations in the nonlinear region than other analyses [e.g. 1875 of June (Derfler)] and in this region it is valid to derive the frequency shift from the Langmuir-Tonks value.

537.56 : 538.56 3293

**Microwave Emission and Absorption at Cyclotron Harmonics of a Warm Plasma.**—G. Bekefi, J. D. Coccoli, E. B. Hooper, Jr, & S. J. Buchsbaum. (*Phys. Rev. Lett.*, 1st July 1962, Vol. 9, No. 1, pp. 6–9.) Results of measurements show anomalous microwave emission and absorption which may be due to a non-Maxwellian electron distribution in the plasma.

537.56 + 537.311.33] : 538.566 3294

**Cyclotron Resonance in a Variable Magnetic Field.**—V. N. Lugovoi. (*Zh. eksp. teor. Fiz.*, Nov. 1961, Vol. 41, No. 5(11), pp. 1562–1565.) The electrical conductivity tensor is calculated for an electron gas in a magnetic field with a variable component parallel to the constant component.

537.56 : 538.566 3295

**Determination of Plasma Properties by Free-Space Microwave Techniques.**

—R. Buser & W. Buser. (*J. appl. Phys.*, July 1962, Vol. 33, No. 7, pp. 2275–2282.) Time-resolved free-space measurements are used to study the loss mechanisms in the afterglow of an intense He discharge between 100 and 1 000 $\mu$.

537.56: 538.566 **3296**

**Nonlinear Oscillations of a Two-Component Plasma in a Magnetic Field.**—Ts. D. Loladze & N. L. Tsintsadze. (*Zh. tekh. Fiz.*, Nov. 1961, Vol. 31, No. 11, pp. 1298–1301.) Determination of the velocity of a nonlinear wave and the width of a single pulse.

537.56: 538.566 **3297**

**The Measurement of Plasma Parameters in a Magnetic Field.**—I. V. Dubovoĭ & A. G. Ponomarenko. (*Zh. tekh. Fiz.*, Nov. 1961, Vol. 31, No. 11, pp. 1302–1308.)

537.56: 538.566 **3298**

**The Dispersion Equation for an Extraordinary Wave Moving in a Plasma Across an External Magnetic Field.**—Yu. N. Dnestrovskiĭ & D. P. Kostomarov. (*Zh. eksp. teor. Fiz.*, Nov. 1961, Vol. 41, No. 5(11), pp. 1527–1535.) Determination of the frequency ranges for which wave propagation occurs without damping.

537.56: 538.63 **3299**

**Electron Energy Distribution in Slightly Ionized Air under the Influence of Electric and Magnetic Fields.**—N. P. Carleton & L. R. Megill. (*Phys. Rev.*, 15th June 1962, Vol. 126, No. 6, pp. 2089–2099.) An analysis of the Boltzmann equation and a discussion of typical properties of some numerical solutions.

537.56: 538.63 **3300**

**Convection of the Plasma of a Positive Column in a Magnetic Field.**—B. B. Kadomtsev. (*Zh. tekh. Fiz.*, Nov. 1961, Vol. 31, No. 11, pp. 1273–1283.) Investigation of plasma turbulence in the presence of a strong longitudinal magnetic field.

537.56: 538.63 **3301**

**Radiation of Plasma Waves by a Charge Moving in a Magnetoactive Plasma.**—V. Ya. Eĭdman. (*Zh. eksp. teor. Fiz.*, Dec. 1961, Vol. 41, No. 6(12), pp. 1971–1977.) Expressions are derived for the spectral and the spatial energy distributions of plasma waves radiated by the moving charge.

537.56: 621.372.8 **3302**

**The Problem of Matching Plasma Waveguides.**—S. S. Kalmykova. (*Zh. tekh. Fiz.*, Nov. 1961, Vol. 31, No. 11, pp. 1374–1378.) Mathematical analysis of the reflection of the e.m. energy by a semi-infinite plasma waveguide with particle density of $10^8$–$10^{11}$cm$^{-3}$.

538.3: 532.5: 551.510.535 **3303**

**Eikonal Method in Magnetohydrodynamics.**—S. Weinberg. (*Phys. Rev.*, 15th June 1962, Vol. 126, No. 6, pp. 1899–1909.) The method is extended to waves with several components propagating in inhomogeneous anisotropic media, and is applied to pure magnetohydrodynamic disturbances and the problem of computing ray paths of disturbances in the ionosphere.

538.566 + 534.2 **3304**

**Propagation of Spherical Waves in Thin Plates and Narrow Slits.**—H. Ott. (*Z. angew. Phys.*, Feb. 1962, Vol. 14, No. 2, pp. 74–86.) Investigation of acoustic and e.m. wave propagation for the case of a point source situated inside a plane-parallel plate, of whose boundaries at least one is 'transparent'. Special cases considered are underwater sound transmission in shallow water, and e.m. wave propagation in a dielectric slab, free-standing or resting on a metal surface.

538.566: 535.42 **3305**

**On the Diffraction of a Pulse by a Half-Plane.**—R. C. T. da Costa. (*Nuovo Cim.*, 1st July 1962, Vol. 25, No. 1, pp. 69–85. In English.) Standard 'knife-edge' theory indicates the formation of an energy reservoir near the edge which reradiates to produce the diffracted pulse. See also 3236 above.

538.566: 537.533 **3306**

**Interaction between an Obliquely Incident Plane Electromagnetic Wave and an Electron Beam in the Presence of a Static Magnetic Field of Arbitrary Strength.**—K. H. B. Wilhelmsson. (*J. Res. nat. Bur. Stand.*, July/Aug. 1962, Vol. 66D, No. 4, pp. 439–451.)

538.569.4: 621.375.9: 535.61-1 **3307**

**Continuous Operation of the $CaF_2$: $Dy^{2+}$ Optical Maser.**—L. F. Johnson. (*Proc. Inst. Radio Engrs*, July 1962, Vol. 50, No. 7, pp. 1691–1692.) Lifetime and spectroscopic data are reported.

538.569.4: 621.375.9: 535.61-1 **3308**

**Continuous Operation of a $CaF_2$: $Dy^{2+}$ Optical Maser.**—A. Yariv. (*Proc. Inst. Radio Engrs*, July 1962, Vol. 50, No. 7, pp. 1699–1700.) Constructional details are given together with the results obtained.

538.569.4: 621.375.9: 535.61-2 **3309**

**The Role of Anomalous Dispersion in the Operation of Optical Masers.**—A. Kastler. (*Ann. Phys., Paris*, Jan./Feb. 1962, Vol. 7, Nos. 1/2, pp. 57–60.) An examination of the dispersion curve and the energy dissipation time of a medium capable of maintaining self-oscillation.

538.569.4: 621.375.9: 535.61-2 **3310**

**Model for Transient Oscillations in a Three-Level Optical Maser.**—J. I. Kaplan & R. Zier. (*J. appl. Phys.*, July 1962, Vol. 33, No. 7, pp. 2372–2375.) The transient response of the optical maser is calculated for a system of homogeneously broadened atoms coupled to one homogeneously broadened cavity mode.

538.569.4: 621.375.9: 535.61-2 **3311**

**The Condition for Self-Excitation of a Laser.**—V. M. Faĭn & Ya. I. Khanin. (*Zh. eksp. teor. Fiz.*, Nov. 1961, Vol. 41, No. 5(11), pp. 1498–1502.) Analysis for a molecular oscillator with a cavity resonator whose dimensions are much greater than the wavelength produced.

538.569.4: 621.375.9: 535.61-2 **3312**

**Measurement of Laser Output by Light Pressure.**—J. J. Cook, W. L. Flowers & C. B. Arnold. (*Proc. Inst. Radio Engrs*, July 1962, Vol. 50, No. 7, p. 1693.) A simple torsion pendulum is described which enables the pulse energy radiated from a laser oscillation to be measured by the pressure exerted on a mirror.

538.569.4: 621.375.9: 535.61-2 **3313**

**Continuous Gas Maser Operation in the Visible.**—A. D. White & J. D. Rigden. (*Proc. Inst. Radio Engrs*, July 1962, Vol. 50, No. 7, p. 1697.) Details of tests made to study the mechanism associated with transmissions from a He-Ne maser discharge tube radiating at 6 328 Å.

538.569.4: 621.375.9: 535.61-2 **3314**

**Aspects of the Construction of He-Ne Lasers for Communication Systems.**—D. Gloge. (*Frequenz*, May 1962, Vol. 16, No. 5, p. 196.) Note of investigations on a He-Ne optical maser with external confocal mirrors [e.g. 1898 of June (Rigrod et al.)] to determine whether the resonator length can be reduced so as to increase the spacing between laser resonance frequencies. A length ~30 cm appears feasible.

538.569.4: 621.375.9: 535.61-2 **3315**

**Zeeman Effect in Gaseous Helium-Neon Optical Maser.**—H. Statz, R. Paananen & G. F. Koster. (*J. appl. Phys.*, July 1962, Vol. 33, No. 7, pp. 2319–2321.) In a magnetic field the maser output contains differently polarized radiations of slightly different frequencies. For a field parallel to the maser axis, a polarizer in the beam will give rise to amplitude-modulated light.

538.569.4: 621.375.9: 535.61-2 **3316**

**Magnetostrictively Tuned Optical Maser.**—W. R. Bennett, Jr, & P. J. Kindlmann. (*Rev. sci. Instrum.*, June 1962, Vol. 33, No. 6, pp. 601–605.) A description of a He-Ne maser of the plane-parallel Fabry-Perot type in which angular adjustments and plate separation are controlled by the distortion of a rigid nilvar mounting frame.

538.569.4: 621.375.9: 535.61-2 **3317**

**On the Modulation of Optical Masers.**—F. S. Barnes. (*Proc. Inst. Radio Engrs*, July 1962, Vol. 50, No. 7, pp. 1686–1687.) The modulation obtainable by Stark and Zeeman effects is too small to be of use. An alternative method is described, based on the modulation of the dielectric constant of a Kerr cell or ADP crystal between the maser medium and one reflector.

538.569.4: 621.375.9: 535.61-2 **3318**

**A Unidirectional Travelling-Wave Optical Maser.**—J. E. Geusic & H. E. D. Scovil. (*Bell Syst. tech. J.*, July 1962, Vol. 41, No. 4, pp. 1371–1397.) The basic concepts of the device are presented and details of feasibility tests are given.

538.569.4: 621.375.9: 535.61-2 **3319**

**Effects of Elevated Temperatures on the Fluorescence and Optical Maser Action of Ruby.**—J. P. Wittke. (*J. appl. Phys.*, July 1962, Vol. 33, No. 7, pp. 2333–

2335.) The results of measurements of λ, line-width and fluorescence efficiencies in the temperature range 300–500°K are used to explain degradation of laser performance.

538.569.4: 621.375.9: 535.61-2 **3320**
**Emission Patterns of a Ruby Laser.**—E. S. Dayhoff. (*Proc. Inst. Radio Engrs*, July 1962, Vol. 50, No. 7, p. 1684.) Investigation of the nature of activation of the filamentary modes of ruby laser crystals by means of high-speed cinematography.

538.569.4: 621.375.9: 535.61-2 **3321**
**Control of Ruby Laser Oscillation by an Inhomogeneous Magnetic Field.**—H. C. Nedderman, Y. C. Kiang & F. C. Unterleitner. (*Proc. Inst. Radio Engrs*, July 1962, Vol. 50, No. 7, pp. 1687–1688.) A simple experiment is described to test the feasibility of using the Zeeman effect for modulation of stimulated-emission gain in optically pumped ruby. Oscilloscope traces indicate positive results.

538.569.4: 621.375.9: 535.61-2 **3322**
**Side Emission from Ruby Laser Rods.**—A. Szabo & F. R. Lipsett. (*Proc. Inst. Radio Engrs*, July 1962, Vol. 50, No. 7, p. 1690.) Tests were made to determine the cause of inconstancy of spontaneous emission during oscillation. The steep rise in side emission was not a direct result of the laser pulse.

538.569.4: 621.375.9: 535.61-2 **3323**
**Time Coherence in Ruby Lasers.**—J. F. Ready. (*Proc. Inst. Radio Engrs*, July 1962, Vol. 50, No. 7, pp. 1695–1696.) The coherence time for laser emissions cannot be obtained by making the same assumptions as are made for incoherent light; reference is made to published measurements which confirm this. Further experiments are suggested.

538.569.4: 621.375.9: 535.61-2 **3324**
**A High-Energy Laser using a Multi-elliptical Cavity.**—C. Bowness, D. Missio & T. Rogala. (*Proc. Inst. Radio Engrs*, July 1962, Vol. 50, No. 7, pp. 1704–1705.) The light energy concentrated on a ruby during flashing is increased by using a number of flash lamps, each enclosed in a cavity whose cross-section is an ellipse. These ellipses have a common focal line constituting the axis of the ruby rod.

538.569.4: 621.375.9: 535.61-2 **3325**
**Time Dependence of the Frequency and Line Width of the Optical Emission from a Pulsed Ruby Maser.**—G. R. Hanes & B. P. Stoicheff. (*Nature, Lond.*, 11th Aug. 1962, Vol. 195, No. 4841, pp. 587–589.) Close to threshold, ruby masers oscillate in a few modes only, and the apparent multiplicity of narrow frequency components arises from the combined effects of the 'spiking' phenomenon and the thermal drift of the optical length of the maser cavity.

539.2: 538.6 **3326**
**Bloch Electrons in a Magnetic Field.**—E. I. Blount. (*Phys. Rev.*, 1st June 1962, Vol. 126, No. 5, pp. 1636–1653.) Kohn's derivation of the effective Hamiltonian (1196 of 1960) is simplified.

## GEOPHYSICAL AND EXTRATERRESTRIAL PHENOMENA

523.164 **3327**
**The Radio Spectrum of Supernova Remnants.**—D. E. Harris. (*Astrophys. J.*, May 1962, Vol. 135, No. 3, pp. 661–678.) The observed spectral index distribution is interpreted in terms of age-dependent parameters. 40 references.

523.164 **3328**
**Radio Sources containing Peculiar Ellipticals.**—J. L. Greenstein. (*Astrophys. J.*, May 1962, Vol. 135, No. 3, pp. 679–683.) Observations of 3C442 and of Hercules-A are compared with observations of the galaxies identifiable with them.

523.164 **3329**
**Absorption by Intergalactic Hydrogen.**—G. B. Field. (*Astrophys. J.*, May 1962, Vol. 135, No. 3, pp. 684–693.) Possible states of the gas are inferred from an experiment indicating less than 0·25% opacity.

523.164 **3330**
**Cross Modulation of Cosmic Noise.**—R. F. Benson. (*J. geophys. Res.*, June 1962, Vol. 67, No. 6, pp. 2569–2572.) The experiments so far performed show that useful measurements of electron density can probably be obtained by cross-modulating 17·5-Mc/s cosmic noise with a 4·9-Mc/s disturbing transmitter.

523.164 **3331**
**A Correlation between the Spectra of Nonthermal Radio Sources and their Brightness Temperatures.**—K. I. Kellermann, R. J. Long, L. R. Allen & M. Moran. (*Nature, Lond.*, 18th Aug. 1962, Vol. 195, No. 4842, pp. 692–693.) Results of measurements at nine frequencies between 38 and 3 200 Mc/s have been used to determine the spectra of 160 discrete sources. Correlation results are shown graphically.

523.164 **3332**
**A Comparison of Radio Star Scintillations at 1 390 and 79 Mc/s at Low Angles of Elevation.**—H. J. A. Chivers & R. D. Davies. (*J. atmos. terr. Phys.*, July 1962, Vol. 24, pp. 573–584.) Experiments to determine the height at which scintillations are impressed upon the incoming radio waves.

523.164 **3333**
**Brightness Distribution of the Radio Source 14N5A.**—B. Anderson, H. P. Palmer & B. Rowson. (*Nature, Lond.*, 14th July 1962, Vol. 195, No. 4837, pp. 165–166.)

523.164.3 **3334**
**Radio Emission of Venus at 4-mm Wavelength.**—A. G. Kislyakov, A. D. Kuz'min & A. E. Salomonovich. (*Astronom. Zh.*, May/June 1962, Vol. 39, No. 3, pp. 410–417.) Results of observations made with a 22-m radio-telescope during March–May 1961.

523.164.3 **3335**
**Recent Radio Observations of Jupiter at Decameter Wavelengths.**—C. H. Barrow. (*Astrophys. J.*, May 1962, Vol. 135, No. 3, pp. 847–854.) The observations were made at several frequencies and relate to occurrence frequency and probability, spectral characteristics, polarization, and noise outbursts.

523.164.32 **3336**
**Calculations of a Slowly Varying Component at 4·3 mm.**—S. Edelson. (*Astrophys. J.*, May 1962, Vol. 135, No. 3, pp. 827–833.) An estimate of the fluctuations in the sun's brightness temperature that may be attributed to localized dense regions.

523.164.32: 523.75 **3337**
**The Association of Type III Bursts and Solar Flares.**—J. M. Malville. (*Astrophys. J.*, May 1962, Vol. 135, No. 3, pp. 834–846.) Observations during 1959 show the majority of bursts to be related to flare characteristics.

523.164.32: 523.78 **3338**
**Observations of 4·3-mm Radiation during the Solar Eclipse of February 15, 1961.**—C. W. Tolbert & A. W. Straiton. (*Astrophys. J.*, May 1962, Vol. 135, No. 3, pp. 822–826.) A description of the techniques and results of an investigation directed mainly to the measurement of coronal emission.

523.164.32: 621.396.677.83 **3339**
**A New Radioheliograph for Australia.**—E. G. Bowen. (*Nature, Lond.*, 18th Aug. 1962, Vol. 195, No. 4842, pp. 649–650.) A note on the features of the instrument which will operate at 3·5 mm λ with half-power beam width 3·5′ of arc.

523.165 **3340**
**The Cosmic Ray Storm of July 1961.**—S. P. Duggal & M. A. Pomerantz. (*J. Franklin Inst.*, April 1962, Vol. 273, No. 4, pp. 322–329.) A comparison of results of observations at a number of stations.

523.165: 550.385.4 **3341**
**On the Effect of Geomagnetic Fluctuations on Trapped Particles.**—L. Davis, Jr. & D. B. Chang. (*J. geophys. Res.*, June 1962, Vol. 67, No. 6, pp. 2169–2179.) The effect of magnetic variations on trapped electrons is studied using the Fokker-Planck equation. Results similar to those of Parker (533 of 1961) are obtained.

523.165: 550.386 **3342**
**Semidiurnal Variation of Cosmic Rays on Geomagnetically Disturbed Days.**—H. S. Ahluwalia. (*Proc. phys. Soc.*, 1st Aug. 1962, Vol. 80, No. 514, pp. 472–478.) Observations at Ahmedabad and Huancayo show that the semidiurnal variation of cosmic-ray intensity found at equatorial stations is of extraterrestrial origin.

523.165: 551.507.362.2 **3343**
**Pitch Angle Distributions and Mirror-Point Densities in the Outer Radiation Zone.**—T. A. Farley & N. L. Sanders. (*J. geophys. Res.*, June 1962, Vol. 67, No. 6, pp. 2159–2168.) Exact expressions for the equatorial unidirectional intensity and the mirror-point density are presented in simple form. These theoretical results are applied

to the omnidirectional intensities measured by the scintillation and proportional counters on the Explorer VI satellite.

523.78 3344
**Report of the Netherlands Expedition for the Observation of the Total Solar Eclipse on 15th February 1961.**—J. Houtgast. (*Proc. kon. ned. Akad. Wetensch.*, 1962, Series B, Vol. 65, No. 3, pp. 313–322. In English.)

550.383 3345
**Graphic Data on the Earth's Main Magnetic Field in Space.**—R. F. Mlodnosky & R. A. Helliwell. (*J. geophys. Res.*, June 1962, Vol. 67, No. 6, pp. 2207–2214.) Several charts, based on the centred-dipole approximation are given, with details o many of the field parameters and also the gyro-frequency.

550.385.2 3346
**A Particular Geomagnetic Daily Variation ($S_q{}^p$) in the Polar Regions on Geomagnetically Quiet Days.**—T. Nagata & S. Kokubun. (*Nature, Lond.*, 11th Aug. 1962, Vol. 195, No. 4841, pp. 555–557.) The variation is observed in the sunlit polar region as an addition to the extended field, $Sq^o$. Possible theories for its appearance are considered.

550.385.4 3347
**Cause of the Preliminary Reverse Impulse of Storms.**—E. H. Vestine & J. W. Kern. (*J. geophys. Res.*, June 1962, Vol. 67, No. 6, pp. 2181–2188.) Ionospheric electric charge distributions are obtained for sudden commencements, supposing only Hall conductivity is important. An explanation of the reverse impulse is given.

550.385.4 3348
**Rise Times versus Magnitudes of Sudden Commencements of Geomagnetic Storms.**—P. R. Pisharoty & B. J. Srivastava. (*J. geophys. Res.*, June 1962, Vol. 67, No. 6, pp. 2189–2192.) A comparison of the rise times with the magnitudes of positive sudden commencements at Alibag, India, shows that the rise times, which are of the order of 1–6 min, are inversely related to the magnitudes of the s.c's.

550.385.4: 523.165 3349
**Relation between the Outer Radiation Belt and the Earth Storm.**—N. Matuura & S. Yoshida. (*J. Radio Res. Labs, Japan*, Jan. 1962, Vol. 9, No. 41, pp. 1–20.) The mechanism of the time variation of the flux intensity of the outer radiation belt associated with geomagnetic storms has been investigated theoretically and experimentally on the basis of rocket and satellite measurements as well as solar and geophysical data.

550.385.4: 523.75 3350
**On the Effect of a Ring Current on the Terminal Shape of the Geomagnetic Field.**—J. R. Spreiter & A. Y. Alksne. (*J. geophys. Res.*, June 1962, Vol. 67, No. 6, pp. 2193–2205.) A previous investigation [1541 of May (Spreiter & Briggs)] of the shape of the geomagnetic hollow is extended to include the effects of a ring current. The computed results are in agreement with the observations.

550.386 3351
**Diurnal Variation of the Earth's Magnetic Field at Sea.**—M. N. Hill & C. S. Mason. (*Nature, Lond.*, 28th July 1962, Vol. 195, No. 4839, pp. 365–366.) Anomalous variations detected by magnetometers in moored buoys are probably caused by induced electric currents in the sea resulting from tidal motion in the earth's magnetic field.

551.507.362.2 3352
**Perturbations in the Rotational-Translational Motion of a Satellite and Planet resulting from their Flattening.**—V. T. Kondurar'. (*Astronom. Zh.*, May/June 1962, Vol. 39, No. 3, pp. 516–526.) A mathematical analysis is made by assuming two solid bodies with dynamic symmetry. Formulae are derived to determine the perturbations due to flattening.

551.510.535 3353
**On the Absolute Intensity of Incoherent Scatter Echoes from the Ionosphere.**—K. L. Bowles, G. R. Ochs & J. L. Green. (*J. Res. nat. Bur. Stand.*, July/Aug. 1962, Vol. 66D, No. 4, pp. 395–407.) New observations at a station near Lima, Peru, indicate that the average radar cross-section per free electron is close to the theoretical value of one half of the classical Thompson cross-section. This suggests that the ionosphere is usually in a condition of thermal equilibrium between ions and electrons.

551.510.535 3354
**Representation of Diurnal and Geographic Variations of Ionospheric Data by Numerical Methods.**—W. B. Jones & R. M. Gallet. (*J. Res. nat. Bur. Stand.*, July/Aug. 1962, Vol. 66D, No. 4, pp. 419–438.) The problem of representing the complex properties of ionospheric characteristics on a world-wide scale is considered. A method is developed for the determination of ionospheric characteristics, including diurnal variations, by the direct numerical analysis of data without prior manual processing.

551.510.535 3355
**The Distribution of Dense $E_s$ Ionization at High Latitudes.**—L. Thomas. (*J. atmos. terr. Phys.*, July 1962, Vol. 24, pp. 643–658.) I.G.Y. data have been used to study the occurrence of dense $E_s$ at stations in the Arctic and Antarctic continents. The changes in the frequency of occurrence with time of day, season and level of magnetic activity are examined. The solar cycle variation is also studied for Canadian stations.

551.510.535 3356
**Lunar Tidal Variation of Midday Critical Frequencies of the F2 Layer of the Ionosphere in Low Latitudes.**—K. M. Kotadia. (*J. atmos. terr. Phys.*, July 1962, Vol. 24, pp. 659–661.) The phase of the semidiurnal lunar variation reverses between magnetic dips 10·5°N and 24·8°N and its amplitude shows two maxima, one near th: magnetic equator and one near magnetic dip 34 N.

551.510.535 3357
**Variations of some Ionospheric Parameters over a Solar Cycle.**—G. A. M. King & M. D. Lawden. (*J. atmos. terr. Phys.*, July 1962, Vol. 24, pp. 565–568.) Sample ionograms taken at Christchurch, N.Z., are analysed [132 of January (King)] in order to examine the solar cycle variation of basic F-region parameters, rates of electron production and loss, and the scale height of atomic oxygen.

551.510.535 3358
**Variations in the Height of the Peak of the Ionospheric F2 Layer.**—J. W. King & J. L. Scott. (*J. atmos. terr. Phys.*, July 1962, Vol. 24, pp. 569–572.) Day-to-day ch inges in F2-layer height are related to the daily sunspot number. The effect of this relation must be removed before conclusions can be drawn from investigations of small height changes.

551.510.535 3359
**The Equilibrium between the Process of Ionization and the Disappearance of Electrons in tbe Ionosphere.**—A. Haubert. (*J. atmos. terr. Phys.*, July 1962, Vol. 24, pp. 661–663. In French.) The equation relating the rate of change of electron density with production and loss rates is solved for particular cases.

551.510.535 3360
**Seasonal and Latitude Variations of Noon Bearings of E-Region Drifts.**—C. L. Henderson. (*J. atmos. terr. Phys.*, July 1962, Vol. 24, pp. 663–666.) Presents data from 13 stations, and shows the overall variations using the noon bearing as a reference parameter.

551.510.535 3361
**Geographic Distribution of Spread-F in the Arctic.**—R. Penndorf. (*J. geophys. Res.*, June 1962, Vol. 67, No. 6, pp. 2279–2288.) Hourly I.G.Y. data at 34 stations in the Arctic have been analysed to determine the diurnal and seasonal variation of spread-F.

551.510.535 3362
**Diurnal and Seasonal Variation of Spread-F in the Arctic.**—R. Penndorf. (*J. geophys. Res.*, June 1962, Vol. 67, No. 6, pp. 2289–2298.) The diurnal and seasonal variation of spread F has been examined for North American stations using hourly ionosonde data obtained during the I.G.Y.

551.510.535 3363
**Ionospheric Refraction: Part 1—Analytic Solution for an Ionosphere Almost Spherically Stratified.**—R. W. Lowen. (*J. geophys. Res.*, June 1962, Vol. 67, No. 6, pp. 2339–2345.) The errors in the zenithal and azimuthal angles of a distant source, caused by ionospheric refraction, are expressed in terms of integrals over the radial distributions of electron density and of its gradients in latitude and longitude.

551.510.535 3364
**Sudden Frequency Shift Observed at High Frequency during Ionospheric Disturbances.**—L. C. Edwards & G. D. Thome. (*J. geophys. Res.*, June 1962, Vol. 67, No. 6, pp. 2573–2580.) Frequency-

shift measurements show that the sudden change in ionization occurs between the absorption and reflection levels. Additional ionization is created at lower altitudes.

551.510.535: 523.746 **3365**

**The Occurrence and Behaviour of the Sporadic E Layer during the Sunspot Maximum.**—H. Wisbar. (*Frequenz*, June 1962, Vol. 16, No. 6, pp. 216–222.) The investigations are based on $E_s$ records for the period 1957–1961 and are particularly concerned with grazing incidence and the effect on frequencies in the range 50–200 Mc/s. Correlation with geomagnetic effects and spatial correlation with vertical soundings are discussed.

551.510.535: 523.75 **3366**

**Measurement of Electron Densities in the Ionospheric D Region at the Time of a 2+ Solar Flare.**—J. S. Belrose & E. Cetiner. (*Nature, Lond.*, 18th Aug. 1962, Vol. 195, No. 4842, pp. 688–690.) Measurements at Ottawa with high-power transmitters and vertical directive aerial systems were carried out at 2·66 and 6·275 Mc/s. As a result of the flare, an increase in electron density by a factor of ten in the 60–75-km region, and a lowering of the base of the ionosphere were observed.

551.510.535: 523.75 **3367**

**Ionospheric Disturbances Associated with the Solar Flare of September 28, 1961.**—D. P. Kanellakos & O. G. Villard, Jr. (*J. geophys. Res.*, June 1962, Vol. 67, No. 6, pp. 2265–2277.)

551.510.535: 523.78 **3368**

**Investigations of the Ionospheric E Layer during the Total Solar Eclipse of 15th February 1961.**—G. Nestorov & J. Taubenheim. (*J. atmos. terr. Phys.*, July 1962, Vol. 24, pp. 633–642. In German.) An analysis of $f_0E$ data for Sofia and Nessebar (Bulgaria) gives for the effective recombination coefficient of the E layer $\alpha \geqslant 10^{-7}$ cm³/sec. 43% of the ionizing radiation is emitted from two regions situated near the equator at the east and west limbs of the sun's disk.

551.510.535: 535.3 **3369**

**Geometrical Optics of the Ionosphere (Applications to Certain Geophysical Problems).**—É. Argence. (*Cah. Phys.*, March 1962, Vol. 16, No. 139, pp. 93–123.) Doppler and Faraday effects observed using artificial satellites, whistlers, the Luxembourg effect, and studies of Cherenkov radiation are considered.

551.510.535: 538.3: 532.5 **3370**

**Eikonal Method in Magnetohydrodynamics.**—Weinberg. (See 3303.)

551.510.535: 550.385.37 **3371**

**Equatorial Micropulsations and Ionospheric Disturbance Currents.**—R. Hutton. (*Nature, Lond.*, 21st July 1962, Vol. 195, No. 4838, pp. 269–270.) A significant correlation exists between the frequency of commencement of *pc* or *pt* activity with the $S_D$ variation of earth currents at an equatorial station.

551.510.535: 551.507.362.2 **3372**

**Ionospheric Electron Content and Variations Measured by Doppler Shifts in Satellite Transmissions.**—F. de Mendonça. (*J. geophys. Res.*, June 1962, Vol. 67, No. 6, pp. 2315–2337.) A new method of analysis is used. The horizontal gradient of electron content is markedly increased during magnetic storms; on quiet days the gradient is nearly constant and of appreciable magnitude.

551.510.535: 551.594.6 **3373**

**Absorption of Audio-Frequency Electromagnetic Waves Traversing the Ionosphere in the Magneto-ionic Mode.**—G. Altman & H. Cory. (*Bull. Res. Counc. Israel*, April 1962, Vol. 11C, No. 1, pp. 1–18.) "Typical absorption curves for magneto-ionic propagation have been calculated for various geomagnetic latitudes and various values of solar zenith angle. The feasibility of communication with satellites beyond the direct line of sight is evaluated and the connection with 'whistler' and v.l.f. noise radiation is shown."

551.510.535: 551.594.6 **3374**

**A Method for the Determination of Lower-Ionosphere Properties by means of Field Measurements on Sferics.**—F. B. Harris, Jr, & R. L. Tanner. (*J. Res. nat. Bur. Stand.*, July/Aug. 1962, Vol. 66D, No. 4, pp. 463–478.) Detailed consideration of the propagation of a.f. and sub-a.f. waves between the earth and an ionosphere whose conductivity varies continuously with altitude. At frequencies above about 50 c/s the propagation constant can be obtained from measurements of atmospherics by airborne equipment; at lower frequencies ground-based observations of cavity resonance effects in atmospheric noise can be used.

551.510.535: 621.391.812.63 **3375**

**Radio Echoes from Field-Aligned Ionization at the Magnetic Equator.**—W. Ireland & J. Mawdsley. (*J. geophys. Res.*, June 1962, Vol. 67, No. 6, pp. 2583–2585.) Near Singapore echoes were obtained in the 3-m band from a region > 10 km thick at a height of 111 km.

551.510.535: 621.391.812.63.029.4/.5 **3376**

**The Scattering Matrix of the Ionosphere.**—H. Volland. (*Arch. elekt. Übertragung*, July 1962, Vol. 16, No. 7, pp. 328–334.) For very long e.m. waves the ionosphere is shown to behave like a microwave four-port. The scattering matrix of a horizontally stratified ionosphere is obtained for incident plane waves and the reflection matrix is calculated for an ionosphere consisting of an arbitrary number of homogeneous layers of finite thickness.

551.594.6 **3377**

**Theory of Generation of Exospheric Very-Low-Frequency Noise (Hiss).**—R. L. Dowden. (*J. geophys. Res.*, June 1962, Vol. 67, No. 6, pp. 2223–2230.) The travelling-wave-tube amplification process of Gallet & Helliwell (4066 of 1959) is considered in greater detail, taking into account the spiral motion of particles travelling in the magnetic field, the interaction distance for which amplification at any one frequency may occur, and the slowing down of the stream particles by the wave amplification process.

551.594.6 **3378**

**Polar-Cap and Auroral-Zone Absorption Effects on 2·5 and 5·0 Megacycles per Second Atmospheric Radio Noise.**—J. R. Herman. (*J. geophys. Res.*, June 1962, Vol. 67, No. 6, pp. 2299–2308.) Ten polar-cap and auroral-zone absorption events occurring during 1958–1960 are analysed.

551.594.6: 539.16 **3379**

**Electromagnetic Radiation from a Nuclear Explosion in Space.**—W. J. Karzas & R. Latter. (*Phys. Rev.*, 15th June 1962, Vol. 126, No. 6, pp. 1919–1926.) Compton-scatter electrons produced and accelerated by the explosion radiate an e.m. signal. The maximum range for detection if cosmic noise is the limiting factor is 10⁶km. See also 202 of 1961 (Johnson & Lippmann).

551.594.6: 551.510.535 **3380**

**Very-Low-Frequency Discrete Emissions Received at Conjugate Points.**—R. L. Dowden: R. A. Helliwell. (*Nature, Lond.*, 7th July 1962, Vol. 195, No. 4836, pp. 64–65.) Comments on a paper by Lokken et al. (149 of January) and reply by one of the authors.

551.594.6: 551.510.536 **3381**

**Landau Damping of Transverse Waves in the Exosphere by Fast-Particle Fluxes.**—D. A. Tidman & R. K. Jaggi. (*J. geophys. Res.*, June 1962, Vol. 67, No. 6, pp. 2215–2221.) Auroral particle fluxes may cause damping of whistlers in the exosphere. Hydromagnetic waves are not significantly affected by this mechanism.

## LOCATION AND AIDS TO NAVIGATION

621.396.933 **3382**

**Flight Safety.**—O. Heer. (*VDI Z.*, 21st April 1962, Vol. 104, No. 12, pp. 562–565.) Annual review covering changes in flight regulations and recent developments of radio and radar navigational aids. 31 references.

621.396.933 **3383**

**Flight Control Systems.**—G. Klein & G. Z. von Manteuffel. (*VDI Z.*, 21st April 1962, Vol. 104, No. 12, pp. 565–570.) Annual review covering microcircuit techniques, reliability and power supplies, in relation to aircraft guidance and landing systems. 244 references.

621.396.933.2 **3384**

**Some Recent Developments in Marine Navigational Aids.**—J. W. Nichols & A. C. MacKellar. (*J. Brit. Instn Radio Engrs*, July 1962, Vol. 24, No. 1, pp. 87–96. Discussion, pp. 97–99.) Modern navigational aids, such as Decca and Loran, have not entirely replaced the older systems which have been greatly improved by electronic and other automatic devices. The nature of such modifications to fog warning systems, lighthouses, D/F beacons, etc., is described.

621.396.933.2 : 529.786 : 621.391.812.63 **3385**

**Phase Measurements of C.W. Transmissions at 80 kc/s over a 1 900-km Path.**—Belrose. (See 3496.)

621.396.962.23 : 551.507.362.2 **3386**

**Doubling Tracking Accuracy with a Two-Way Doppler System.**—J. A. Huie, R. H. Moehlman, H. R. Dobson & R. H. Kay. (*Electronics*, 20th July 1962, Vol. 35, No. 29, pp. 42–45.) A stationary interrogating station beams a c.w. signal to a satellite transponder which multiplies the frequency of the received signal and retransmits it. Doppler shift data can be extracted at the receiving station.

621.396.969.34 **3387**

**Air Navigation.**—K. E. Karwath. (*VDI Z.*, 21st April 1962, Vol. 104, No. 12, pp. 571–574.) Annual review dealing with computer systems, and various navigation methods and equipment. 26 references.

## MATERIALS AND SUBSIDIARY TECHNIQUES

535.215 **3388**

**An Electro-optical and Electromechanical Effect in SbSI.**—R. Kern. (*J. Phys. Chem. Solids*, March 1962, Vol. 23, pp. 249–253.) An electric field of the order of 5 000 V/cm applied along the *c*-axis of a single crystal of SbSI shifts the optical absorption edge from 6 300 Å to shorter wavelengths by about 80 Å at room temperature. At the same time the crystal is elongated along the *c*-axis by a few tenths of 1%.

535.215 : 546.48'221 **3389**

**X-Ray Damage and its Influence on the Spectral Distribution of Photocurrent in CdS Single Crystals.**—K. W. Böer, E. H. Weber & B. Wojtowicz. (*Z. Phys.*, 21st May 1962, Vol. 168, No. 2, pp. 115–128.) Investigations of photoconductivity at room temperature and −176°C with polarized light on single crystals previously irradiated by X-rays at 60–200 keV.

535.215 : 546.48'221 **3390**

**On the Conductivity of Cadmium Sulphide following Electron Bombardment.**—R. G. Schulze & B. A. Kulp. (*J. appl. Phys.*, July 1962, Vol. 33, No. 7, pp. 2173–2175.) The dark conductivity of fine rod and whisker-type crystals of undoped CdS was increased from $10^{-10}$ to $10^{-3}$ $(\Omega\,cm)^{-1}$ by bombardment with 100-keV electrons. Heat treatment reduced the conductivity to its original level.

535.215 : 546.48'221 **3391**

***p-n* Photovoltaic Effect in Cadmium Sulphide.**—H. G. Grimmeiss & R. Memming. (*J. appl. Phys.*, July 1962, Vol. 33, No. 7, pp. 2217–2222.) 'Front-wall' cells (barrier layer on the side nearest to the light source) are produced from CdS by inwards diffusion and subsequent etching of the metal (Cu, Ag, Ni) which forms the barrier layer. From the results of measurements on such cells it is concluded that the photovoltaic effect is not due to photo-ionization of free-metal electrons, but is due to the presence of a *p-n* layer.

535.37 : 546.47'221 **3392**

**The Brightness of ZnS Phosphors during Short-Term Excitation.**—H. Ball. (*Z. Phys.*, 25th July 1962, Vol. 168, No. 5, pp. 516–529.) The initial luminescence intensity of various phosphors was measured for excitation times in the range $10^{-5}$–1 s. The results confirm that luminescence is due to recombination effects.

535.376 : 546.48'221 **3393**

**Luminous Emission of Cadmium Sulphide Bombarded with Cathode Rays.**—F. Bombré & F. Gans. (*C. R. Acad. Sci., Paris*, 10th April 1961, Vol. 252, No. 15, pp. 2209–2211.) A green luminescence is observed which is dependent on the purity of the material and the density and accelerating potential of the bombarding beam.

535.376 : 546.48'47'221 **3394**

**The Gudden-Pohl Effect in a Zinc-Cadmium Sulphide Phosphor.**—H. Gutjahr. (*Z. Phys.*, 21st May 1962, Vol. 168, No. 2, pp. 199–205.) Report of investigations of luminescence flashes on (Zn, Cd)S phosphors at −120° C.

535.376 : 546.48'47'221 **3395**

**The Enhancement of X-Ray Luminescence by Electric Fields and Infrared Radiation.**—H. Gobrecht, H. E. Gumlich, H. Nelkowski & K. Laemann. (*Z. Phys.*, 12th June 1962, Vol. 168, No. 3, pp. 273–282.) The results of measurements on (Zn,Cd)S phosphors are discussed with reference to the model given in 4166 of 1961 (Gobrecht et al.).

537.227 **3396**

**Far-Infrared Dielectric Dispersion in $BaTiO_3$, $SrTiO_3$ and $TiO_2$.**—W. G. Spitzer, R. C. Miller, D. A. Kleinman & L. E. Howarth. (*Phys. Rev.*, 1st June 1962, Vol. 126, No. 5, pp. 1710–1721.) Room-temperature reflectivity was measured in the wave number range 5 000–70 $cm^{-1}$. Results are analysed by the Kramers-Kronig method and classical dispersion theory.

537.227 : 546.431'824-31 **3397**

**Evidence for Space-Charge Conduction in Barium Titanate Single Crystals.**—A. Branwood, O. H. Hughes, J. D. Hurd & R. H. Tredgold. (*Proc. phys. Soc.*, 1st June 1962, Vol. 79, No. 512, pp. 1161–1165.) Previous conductivity measurements [219 of 1961 (Branwood & Tredgold)] are extended to include crystals with various anode-cathode combinations chosen from Au, Al, Cr, Sn and Ag.

537.227 : 546.431'824-31 **3398**

**The Surface Effect on the Electrical Properties of $BaTiO_3$ Single Crystals.**—H. Toyoda & M. Itakura. (*J. phys. Soc. Japan*, June 1962, Vol. 17, No. 6, pp. 924–931.) Effects of electrode material and atmosphere on the polarization reversal and electrical conduction of $BaTiO_3$ crystals are reported.

537.227 : 546.431'824-31 **3399**

**Etch Pits Corresponding to Dislocations in Barium Titanate Single Crystals.**—S. Waku. (*J. phys. Soc. Japan*, June 1962, Vol. 17, No. 6, pp. 1068–1069.)

537.227 : 547.476.3 **3400**

**Fast Ferroelectric After-Effect Phenomena.**—H. G. Unruh & H. E. Müser. (*Z. angew. Phys.*, March 1962, Vol. 14, No. 3, pp. 121–125.) A rapid constriction of the ferroelectric hysteresis loop observed immediately after application of an alternating field to Rochelle salt is attributed to lattice defects. This effect disappears in fractions of a second, unlike the phenomena described in 3008 of 1959 (Müser).

537.227 : 621.317.335.3 **3401**

**Measurement of Microwave Dielectric Constants of Ferroelectrics: Part 2—Dielectric Constants and Dielectric Losses of $NaNO_2$ and $(Glycine)_3.H_2SO_4$.**—E. Nakamura. (*J. phys. Soc. Japan*, June 1962, Vol. 17, No. 6, pp. 961–966.) Dielectric constants and loss tangents have been measured as a function of temperature. Part 1: 1547 of 1961 (Nakamura & Furuichi).

537.311.31 : 539.23 **3402**

**The Effect of Temperature on the Resistivity of Thin Films of Silver.**—J. Savornin, A. Donnadieu & F. Savornin. (*C. R. Acad. Sci., Paris*, 10th April 1961, Vol. 252, No. 15, pp. 2195–2196.)

537.311.31 : 539.23 **3403**

**Electrical Properties of Thin Nickel Films at Low Temperatures.**—O. S. Galkina, L. A. Chernikova, Chzhan Kai-da (Chang Kai-Ta) & E. I. Kondorskiĭ. (*Zh. eksp. teor. Fiz.*, Dec. 1961, Vol. 41, No. 6(12), pp. 1763–1766.)

537.311.33 **3404**

**Energy-Dependent Bulk Relaxation Time and Surface Transport.**—R. F. Greene. (*J. Phys. Chem. Solids*, April 1962, Vol. 23, pp. 424–425.) Electron transport in the semiconductor space-charge region can be drastically affected by the energy dependence of the bulk relaxation time. The treatment given differs from that of Ciobanu (1980 of June).

537.311.33 **3405**

**Diffusion of Hot and Cold Electrons in Semiconductor Barriers.**—R. Stratton. (*Phys. Rev.*, 15th June 1962, Vol. 126, No. 6, pp. 2002–2014.) The transport equations are derived and applied to a one-dimensional *n*-type-semiconductor/metal contact rectifier for which computer solutions are obtained.

537.311.33 **3406**

**An Electromechanical Effect in Semiconductors.**—J. H. Westbrook & J. J. Gilman. (*J. appl. Phys.*, July 1962, Vol. 33, No. 7, pp. 2360–2369.) The resistance to indentation of semiconducting crystals is lowered by up to 60% by the presence of a small potential (0·05–10 V) between the indenting device and the crystal surface. The effect has been observed in Ge, Si, InSb and SiC.

537.311.33 **3407**

**A New Method for Calculating the Energy Spectrum of Carriers in Semi-**

**conductors: Part 2—Allowing for Spin-Orbit Interaction.**—G. E. Pikus. (*Zh. eksp. teor. Fiz.*, Nov. 1961, Vol. 41, No. 5(11), pp. 1507–1521.) Semiconductors whose wurtzite or Ge lattice structure is deformed are examined and their energy spectrum is calculated. Part 1: *ibid.*, Oct. 1961, Vol. 41, No. 4(10), pp. 1258–1273.

537.311.33 **3408**

**The Measurement of Small Diffusion Depths in Semiconductor Materials.**—G. Schwabe. (*Z. angew. Phys.*, May 1962, Vol. 14, No. 5, pp. 297–299.) A simple method for obtaining a sharp edge in grinding the semiconductor specimen is described; this, in conjunction with a process of Cu plating to make the *p-n* boundary visible, facilitates the measurement of diffusion depths. The plating method is also applicable to $n^+$-$n$ junctions.

537.311.33 **3409**

**Details of Ion Drift in an *n-p* Junction.**—F. A. Lehrer & H. Reiss. (*J. appl. Phys.*, July 1962, Vol. 33, No. 7, pp. 2353–2359.) The motion of Li in an *n-p* junction under reverse bias [see e.g. 2041 of 1960 (Pell)] is discussed. Theory suggests that the 'intrinsic' layer produced by drift under reverse bias is very highly compensated over most of its extent.

537.311.33 **3410**

**Space-Charge Layer Width and Junction Capacitance of a Hyper-abrupt *p-n* Junction.**—H. Nukushina. (*J. phys. Soc. Japan*, June 1962, Vol. 17, No. 6, pp. 941–949.) Studies of the temperature dependence of the space-charge layer width and junction capacitance are reported. At 350°K the space-charge layer is narrower than expected.

537.311.33: 535.211: 538.6 **3411**

**Photomagnetothermal Effect in Semiconductors.**—W. W. Gärtner, C. Loscoe & H. Mette. (*Phys. Rev.*, 1st June 1962, Vol. 126, No. 5, pp. 1680–1684.) A theory is formulated for the establishment of a temperature distribution in a solid by optical excitation of carriers in the presence of a weak magnetic field. Experiment shows that the effect occurs in Ge. For the theory of the related photothermal effect see 3022 of 1961 (Gärtner).

537.311.33: 535.215 **3412**

**Transport in a Semiconductor with Anisotropic Mobilities and the Photo-piezoresistance.**—W. van Roosbroeck & W. G. Pfann. (*J. appl. Phys.*, July 1962, Vol. 33, No. 7, pp. 2304–2309.) Phenomenological formulation, under the assumption of Boltzmann statistics, of current-carrier transport with anisotropic mobilities and diffusivities. The photopiezoresistance effect is treated for a slab, and the theory is given for the photovoltages and currents and for the efficiency of a transducer based on the effect.

537.311.33: 537.312.8 **3413**

**Theory of Localized Spins and Negative Magnetoresistance in the Metallic Impurity Conduction.**—Y. Toyozawa. (*J. phys. Soc. Japan*, June 1962, Vol. 17, No. 6, pp. 986–1004.) The combined effect of electron correlation and random lattice structure in the impurity conduction of semiconductors is investigated.

537.311.33: 537.322.11 **3414**

**Anomalous Seebeck Effect in Semiconductors.**—P. C. Newman. (*Proc. phys. Soc.*, 1st June 1962, Vol. 79, No. 512, pp. 1299–1300.)

537.311.33: 538.614 **3415**

**'Transverse' Arrangement for the Determination of the Faraday Rotation in Semiconductors from a Measurement of Intensity with a Large Aperture and without Analyser.**—F. R. Kessler & E. Bodinet. (*Z. angew. Phys.*, Feb. 1962, Vol. 14, No. 2, pp. 59–63.) In the experimental arrangement described the optical system is transverse to the magnetic field with the semiconductor specimen acting as analyser.

537.311.33: 538.63 **3416**

**Role of Electron-Electron Collisions in Galvanomagnetic Effects.**—B. V. Paranjape & B. U. Stewart. (*Phys. Rev.*, 1st June 1962, Vol. 126, No. 5, pp. 1668–1671.) An additional term is introduced in the Boltzmann equation to account for the effect of electron-electron collisions on the distribution function. Hall effect and magnetoresistance are calculated. See also 492 of 1959 (Keyes).

537.311.33: 538.632 **3417**

**The Resistance and Field of a Small Rectangular Hall Plate.**—J. Haeusler. (*Z. Naturf.*, June 1962, Vol. 17a, No. 6, pp. 506–513.) The analysis is based on Wick's solution of the field problem by conformal representation (3161 of 1954).

537.311.33: 538.632 **3418**

**Hall Effect in Single-Crystal TiC.**—J. Piper. (*J. appl. Phys.*, July 1962, Vol. 33, No. 7, pp. 2394–2395.)

537.311.33: 546.23: 539.23 **3419**

**Measurements of Contact Potential on Films of Pure and Chlorine-Doped Selenium.**—H. Gobrecht, H. J. Reiter & A. Tausend. (*Z. angew. Phys.*, Feb. 1962, Vol. 14, No. 2, pp. 53–59.)

537.311.33: [546.28+546.289 **3420**

**Theory of Shallow Acceptor States in Si and Ge.**—D. Schechter. (*J. Phys. Chem. Solids*, March 1962, Vol. 23, pp. 237–247.) A theoretical investigation of the small acceptor states that arise when a Group III atom is substituted for a lattice atom in a perfect crystal of Si or Ge.

537.311.33: [546.28+546.289 **3421**

**Evaporation of Silicon and Germanium by R.F. Levitation.**—E. A. Roth, E. A. Margerum & J. A. Amick. (*Rev. sci. Instrum.*, June 1962, Vol. 33, No. 6, pp. 686–687.)

537.311.33: [546.28+546.289 **3422**

**The Nonlinear Behaviour of High-Power Centimetre-Wave Absorption by Carriers in *n*-Germanium and Silicon Crystals.**—S. Kobayashi & M. Aoki. (*J. phys. Soc. Japan*, June 1962, Vol. 17, No. 6, pp. 1066–1067.) Decreased microwave attenuation with increased incident power is observed.

537.311.33: 546.28 **3423**

**Non-ohmic Behaviour in Silicon.**—E. A. Davies & D. S. Gosling. (*J. Phys. Chem. Solids*, April 1962, Vol. 23, pp. 413–416.) Experiments were carried out on high-resistivity *n*-type Si with applied fields of up to 60 kV/cm. The variation of current density and of mobility as a function of the electric field is illustrated graphically.

537.311.33: 546.28 **3424**

**The Dislocation Density and Lifetime of Zone-Pulled Silicon Single Crystals as a Function of Pulling Speed and Heat Treatment.**—O. Böttger & E. Richter. (*Z. Naturf.*, June 1962, Vol. 17a, No. 6, pp. 526–529.)

537.311.33: 546.28 **3425**

**The Lifetime of Zone-Pulled and Metal-Doped Silicon Single Crystals.**—O. Böttger & E. Richter. (*Z. Naturf.*, June 1962, Vol. 17a, No. 6, pp. 529–532.)

537.311.33: 546.28 **3426**

**Method for Evaluating the Quality of an Epitaxial Overgrowth Layer of Silicon on a Single-Crystal Silicon Seed.**—D. M. Jackson, J. B. Newkirk & M. J. Urban. (*J. appl. Phys.*, July 1962, Vol. 33, No. 7, pp. 2301–2304.) X-ray diffraction photographs are used.

537.311.33: 546.28: 539.23 **3427**

**Some Properties of Evaporated Silicon Films.**—Y. Kataoka. (*J. phys. Soc. Japan*, June 1962, Vol. 17, No. 6, pp. 967–969.) The temperature dependence of the resistivity and Hall mobility of Si films is investigated.

537.311.33: 546.28: 539.23 **3428**

**A Method for Measuring the Thickness of Epitaxial Silicon Films.**—W. C. Dash. (*J. appl. Phys.*, July 1962, Vol. 33, No. 7, pp. 2395–2396.) The method described is based on the properties of stacking faults in the epitaxial layers.

537.311.33: 546.28: 621.3.032.27 **3429**

**Some Electrical Properties of the Porous Graphite Contact on *p*-Type Silicon.**—G. G. Harman, T. Higier & O. L. Meyer. (*J. appl. Phys.*, July 1962, Vol. 33, No. 7, pp. 2206–2208.) Current through the sample reaches a saturation level that is inversely proportional to the amount of adhered water vapour. An electron band model, which includes a trap-dominated inversion layer, is presented to explain the phenomena.

537.311.33: 546.289 **3430**

**Drift Velocity and Anisotropy of Hot Electrons in *n*-Germanium.**—H. G. Reik & H. Risken. (*Phys. Rev.*, 1st June 1962, Vol. 126, No. 5, pp. 1737–1746.) Drift velocity and the angle of its direction relative to that of the electric field are calculated.

537.311.33: 546.289 **3431**

**Hot-Electron Effect in Cyclotron Resonance of Germanium.**—H. Kawamura, M. Fukai & Y. Hayashi. (*J. phys. Soc. Japan*, June 1962, Vol. 17, No. 6, pp. 970–974.) Changes in the line width of the cyclotron resonance spectrum of Ge as a function of incident microwave power are interpreted in terms of changes in effective electron temperature.

537.311.33: 546.289 **3432**

**Electrical and Optical Investigation of the Donor Fo mation in Oxygen-Doped Germanium.**—W. Kaiser. (*J. Phys. Chem. Solids*, March 1962, Vol. 23, pp. 255–260.)

537.311.33: 546.289 **3433**

**Impact Ionization in Zinc-Doped Germanium at Low Temperatures.**—A. Zylbersztejn. (*J. Phys. Chem. Solids*, March 1962, Vol. 23, pp. 297–309.) Ionization breakdown was observed successively on two acceptor levels of Zn. The variation of Hall mobility with electric field is qualitatively explained and a generalized mechanism for negative resistance is given.

537.311.33: 546.289: 535.215: 538.63 **3434**

**The Photomagnetic Effect in a *p-n* Junction.**—I. K. Kikoin & I. I. Nikolaev. (*Zh. eksp. teor. Fiz.*, Nov. 1961, Vol. 41, No. 5(11), pp. 1692–1694.) Experiments on Ge specimens are described which were carried out to check whether the photomagnetoelectric effect [e.g. 241 of 1961 (Brand et al.)] is produced in the blocking layer between a semiconductor and its metal electrodes.

537.311.33: 546.289: 537.533.73 **3435**

**Intensity Measurements on Medium-Speed Electrons by means of the Conductivity Effect of CdS, and Application to Electron Diffraction in Amorphous Germanium.**—K. Kambe. (*Z. Naturf.*, June 1962, Vol. 17a, No. 6, pp. 499–505.)

537.311.33: 546.289: 621.385.833 **3436**

**Electron-Microscope Observations on Germanium after Plastic Deformation and Cathode Sputtering.**—W. Reissler & K. Kleinhenz. (*Z. angew. Phys.*, Feb. 1962, Vol. 14, No. 2, pp. 86–88.) The thickness of Ge specimens previously ground to 0·2 mm is further reduced by cathode sputtering to < 0·5 $\mu$ to make the specimen suitable for observation by transmission electron microscope. The method has been used for investigation of lattice faults.

537.311.33: 546.3-1'87'23: 538.632 **3437**

**Change of the Concentration of Current Carriers in Bismuth due to Selenium Impurities.**—N. E. Alekseevskiĭ & T. I. Kostina. (*Zh. eksp. teor. Fiz.*, Dec. 1961, Vol. 41, No. 6(12), pp. 1722–1724.) From the value of Hall effect in strong magnetic fields it is found that one atom of Se changes the electron concentration in Bi by $3 \times 10^{-2} \pm 10\%$ electrons per atom.

537.311.33: 546.3-1'87'86 **3438**

**The Influence of Antimony Impurities on the de Haas-van Alphen Effect in Bismuth.**—N. B. Brandt & V. V. Shchekochikhina. (*Zh. eksp. teor. Fiz.*, Nov. 1961, Vol. 41, No. 5(11), pp. 1412–1420.) Investigations on Bi-Sb alloys with up to 1% Sb, in the temperature range 1·6–4·2 K.

537.311.33: 546.47-31: 538.569.4 **3439**

**Paramagnetic Resonance of $Mn^{++}$ Ions in Synthetic and Natural ZnO Crystals: Part I—'Permissible' Transitions $\Delta M = \pm 1$, $\Delta M = 0$.**—J. Schneider & S. R. Sircar. (*Z. Naturf.*, July 1962, Vol. 17a, No. 7, pp. 570–577.)

537.311.33: 546.654'733 **3440**

**Semiconductor Properties of Lanthanum Cobaltite.**—P. Gerthsen & K. H. Härdtl. (*Z. Naturf.*, June 1962, Vol. 17a, No. 6, pp. 514–521.) Measurement of thermo-e.m.f., electrical conductivity and Hall effect on *n*- and *p*-type specimens of $LaCoO_3$ over an extended temperature range. The results are interpreted on the basis of a polaron model.

537.311.33: 546.681'18 **3441**

**Some Properties of Copper-Doped Gallium Phosphide.**—J. W. Allen & R. J. Cherry. (*J. Phys. Chem. Solids*, May 1962, Vol. 23, pp. 509–511.) Cu produces an acceptor level 0·68 eV above the valence band. Semi-insulating GaP made by diffusing Cu into initially *n*-type material can have a resistivity of $10^{10}\Omega$.cm at room temperature.

537.311.33: 546.681'19 **3442**

**On the Preparation of High-Purity Gallium Arsenide.**—N. G. Ainslie, S. E. Blum & J. F. Woods. (*J. appl. Phys.*, July 1962, Vol. 33, No. 7, pp. 2391–2393.)

537.311.33: 546.681'19: 538.639 **3443**

**Nernst Effect in *n*-Type GaAs.**—R. O. Carlson, S. J. Silverman & H. Ehrenreich. (*J. Phys. Chem. Solids*, April 1962, Vol. 23, pp. 422–424.) No sign reversal of the Nernst coefficient was obtained for several samples of GaAs and acoustic-mode lattice scattering is ruled out as a dominant scattering mechanism in nondegenerate samples. See e.g. 1292 of 1960 (Emel'yanenko & Nasledov).

537.311.33 **3444**
: [546.682'19 + 546.682'86 + 546.681'19

**The Magnetic Electron Susceptibility of InAs, InSb and GaAs.**—G. Römelt & D. Geist. (*Z. angew. Phys.*, Feb. 1962, Vol. 14, No. 2, pp. 99–102.) Experimental results obtained at room temperature and at 140°K are given and discussed.

537.311.33: 546.682'19: 538.632 **3445**

**Quantum Galvanomagnetic Effects in *n*-Type InAs.**—Kh. I. Amirkhanov, R. I. Bashirov & Yu. É. Zakiev. (*Zh. eksp. teor. Fiz.*, Dec. 1961, Vol. 41, No. 6(12), pp. 1699–1703.) The Hall effect and electrical resistance were investigated in strong pulsed magnetic fields at temperatures between 20 and 360°K.

537.311.33: 546.682'86 **3446**

**Alpha and Beta Grain Boundaries in Indium Antimonide.**—R. K. Mueller & R. L. Jacobson. (*J. appl. Phys.*, July 1962, Vol. 33, No. 7, pp. 2341–2345.) Alpha boundaries present a barrier to current flow in *n*- and *p*-type material; beta boundaries only prevent flow in *p*-type material. A theoretical model is proposed.

537.311.33: 546.873'241 **3447**

**Copper Exudation at the Surface of Bismuth Telluride.**—G. Haacke. (*Z. angew. Phys.*, Feb. 1962, Vol. 14, No. 2, pp. 102–105.) Investigation of aging effects in Cu-doped $Bi_2Te_3$.

537.311.33: 546.873'86'241 **3448**

**Properties of $Bi_2Te_3$-$Sb_2Te_3$ Alloys.**—M. J. Smith, R. J. Knight & C. W. Spencer. (*J. appl. Phys.*, July 1962, Vol. 33, No. 7, pp. 2186–2190.)

537.311.33: 546.873'86'241 **3449**

**$Bi_2Te_3$-$Sb_2Te_3$ Alloys with Additions of Tellurium and Selenium.**—J. Rupprecht. (*Z. Naturf.*, July 1962, Vol. 17a, pp. 628–629.) Note on thermoelectric properties of alloys containing various percentages of Te and Se.

537.311.33: 621.3.032.27 **3450**

**Some Properties of Dirty Contacts on Semiconductors and Resistivity Measurements by a Two-Terminal Method.**—G. G. Harman & T. Higier. (*J. appl. Phys.*, July 1962, Vol. 33, No. 7, pp. 2198–2206.) The type of contact considered is separated from the bulk by such barriers as surface states, atmospheric contaminants, oxide layers and chemical films, and is easily applied or removed. From experimental investigations on SiC and Si two types of barrier film were found; one resulted in tunnelling, the other in avalanche breakdown.

537.312.62 **3451**

**Characteristics and a New Application of High-Field Superconductors.**—P. S. Swartz & C. H. Rosner. (*J. appl. Phys.*, July 1962, Vol. 33, No. 7, pp. 2292–2300.) A superconducting magnetic-flux compressor is proposed in which fields > 100 kilo-oersted should be attained.

537.312.62 **3452**

**Some Experimental Consequences of Flux Conservation within Multiply-Connected Superconductors.**—A. F. Hildebrandt, D. D. Elleman, F. C. Whitmore & R. Simpkins. (*J. appl. Phys.*, July 1962, Vol. 33, No. 7, pp. 2375–2377.) A method of flux compression by 'pumping' is described.

538.221 **3453**

**Ferro- and Antiferro-magnetism in a Cubic Cluster of Spins.**—G. Dresselhaus. (*Phys. Rev.*, 1st June 1962, Vol. 126, No. 5, pp. 1664–1667.) An exact solution is given to the Heisenberg Hamiltonian for eight spins.

538.221 **3454**

**Micromagnetic Calculation of the Magnetization in the Vicinity of Non-magnetic Inclusions in Ferromagnetic Materials.**—H. Kronmüller. (*Z. Phys.*, 25th July 1962, Vol. 168, No. 5, pp. 478–494.) The field-strength dependence of reversible susceptibility in the presence of non-magnetic cavities and at high field strengths is discussed; differences relative to calculations by Néel are attributed to the effects of exchange energy.

538.221 **3455**

**The Effect of Internal Stresses and of Field Strength on the Magnetic Domain Structure of Iron-Silicon Single Crystals.**—H. Träuble. (*Z. Metallkde*, April 1962, Vol. 53, No. 4, pp. 211–231.)

538.221 **3456**

**Statistical Stability of the Preisach Diagram for Particles of $\gamma$-$Fe_2O_3$.**—G. Bate. (*J. appl. Phys.*, July 1962, Vol. 33, No. 7, pp. 2263–2269.) Experimental evidence shows that, between certain limits, the diagram for $\gamma$-$Fe_2O_3$ particles is statistically stable. The computed diagram is used to predict the ascending remanence curve after a.c. demagnetization.

538.221 : 061.3 **3457**

**Papers Presented at the Convention of the Working Group on Ferromagnetism in Marburg a.d. Lahn from 27th to 29th September 1961.**—(*Z. angew. Phys.*, April 1962, Vol. 14, No. 4, pp. 177–275.) The text of over 30 papers is given covering magnetization and magnetic structure of thin films, ferromagnetic resonance and the characteristics of ferrites and permanent-magnet material.

538.221 : 534.231-8 **3458**

**The Reduction of Coercivity by Ultrasonic Radiation.**—W. Breuer & J. Jaumann. (*Z. angew. Phys.*, May 1962, Vol. 14, No. 5, pp. 306–313.) Investigation of the magnetic properties of small ferromagnetic specimens in ultrasonic fields at 600 kc/s with an intensity of 70 kp/cm². See also 2306 of 1961 (Haacke & Jaumann).

538.221 : 538.248 **3459**

**The Remanence in Ideal Magnetization.**—M. Kornetzki. (*Z. angew. Phys.*, March 1962, Vol. 14, No. 3, pp. 164–168.) Theory of the ideal magnetization process on the basis of the Preisach diagram. A comparison is made with the results of measurements.

538.221 : 538.569.4 **3460**

**Investigations of the Influence of Surface Condition and Lattice Defects on the Line Width of Ferromagnetic Resonance of Polycrystalline Metals.**—E. Biller. (*Z. Naturf.*, July 1962, Vol. 17a, No. 7, pp. 559–569.) Experimental results obtained mainly on Ni specimens are analysed.

538.221 : 539.23 **3461**

**Magnetic Properties of Ferromagnetic Films: Part 3—'Ripple Theory' of Coercivity.**—H. Rother. (*Z. Phys.*, 12th June 1962, Vol. 168, No. 3, pp. 283–291.) Parts 1 & 2: 3109 of September.

538.221 : 539.23 **3462**

**Domain Observations on a Nickel-Iron Thin Film.**—L. F. Bates & R. Carey. (*Proc. phys. Soc.*, 1st June 1962, Vol. 79, No. 512, pp. 1245–1251.) The magnetization reversal process was observed in different transverse fields and the resultant variation in domain wall coercivity is compared with theory.

538.221 : 621.3.014.12 **3463**

**The Shape of Specimen for the Measurement of the Skin Effect in Ferromagnetic Strips.**—J. E. L. Bishop. (*Proc. phys. Soc.*, 1st June 1962, Vol. 79, No. 512, pp. 1263–1270.) An analysis of the current distribution in a stack of strips with adjacent strips carrying current in alternate directions.

538.221 : 621.318.134 **3464**

**Magnetic Properties of Mixed Ferrites.**—J. G. Booth & J. Crangle. (*Proc. phys. Soc.*, 1st June 1962, Vol. 79, No. 512, pp. 1271–1281.)

Part 1—Behaviour near the Curie Point (pp. 1271–1277).

Part 2—Superparamagnetism and Exchange Anisotropy in a Cobalt-Zinc Ferrite (pp. 1278–1281).

538.221 : 621.318.134 **3465**

**Mechanism of Disaccommodation in Ferrite.**—A. Yanase. (*J. phys. Soc. Japan*, June 1962, Vol. 17, No. 6, pp. 1005–1011.) The decrease, after demagnetization, of the magnetic permeability of Ni-Zn ferrite is studied.

538.221 : 621.318.134 **3466**

**Dislocations in Manganese-Ferrite Single Crystals.**—I. Hanke & H. Burger. (*Z. angew. Phys.*, March & May 1962, Vol. 14, Nos. 3 & 5, pp. 168–174 & 301–306.)

Part 1—Detection of Dislocations on Low-Index Surfaces and the Effects of Various Etchants (pp. 168–174).

Part 2—Step and Screw-Type Dislocations: Distribution of Dislocations over the Crystal Cross-Section (pp. 301–306).

538.221 : 621.318.134 **3467**

**Some Microwave Measurements on Nickel Ferrite-Aluminates and Nickel-Zinc Ferrite-Aluminates.**—E. N. Bramley & A. C. Gordon-Smith. (*Proc. Instn elect. Engrs*, Part B, July 1962, Vol. 109, No. 46, pp. 325–335.) X-band magnetic properties under an applied magnetic field depart considerably from simple Landau-Lifshitz behaviour. Resonant-cavity measurements are also compared with transmission measurements using thin slabs in a rectangular waveguide.

538.221 : 621.318.134 **3468**

**On the Spin-Wave Spectrum in the Structure of Garnets.**—B. Dreyfus. (*J. Phys. Chem. Solids*, March 1962, Vol. 23, pp. 287–295. In French.) A classical treatment of spin waves applied to the garnet structure gives in a compact form for $k = 0$ the 'optical' frequencies and the corresponding spin-wave modes. An explicit computation has been made for Gd garnet with the purpose of adapting the spectrum to the specific heat curve.

538.221 : 621.318.134 **3469**

**Influence of Crystal Growth on Domain Behaviour in Yttrium Iron Garnet.**—R. A. Lefever, A. B. Chase & K. A. Wickersheim. (*J. appl. Phys.*, July 1962, Vol. 33, No. 7, pp. 2249–2250.) Domain patterns show pronounced discontinuities at the lines of intersection of vicinal faces. Differences in magnetic behaviour in the regions delineated by the discontinuities are related to orientated strains resulting from the growth processes.

538.221 : 621.318.134 : 681.142 **3470**

**Nucleation as a Model for the Magnetization Reversal of Ferrite Cores for Switching and Storage.**—H. Stegmeier. (*Z. angew. Phys.*, March 1962, Vol. 14, No. 3, pp. 157–164.) Modification of the theory of flux reversal given by Menyuk & Goodenough (1713 of 1955).

538.221 : 621.318.2 **3471**

**Platinax II: A New Powerful Permanent-Magnet Alloy.**—R. A. Mintern. (*Instrum. Practice*, March 1962, Vol. 16, No. 3, pp. 289–292.) The Co-Pt alloy described has an energy product $BH_{max} = 9{\cdot}2 \times 10^6$ G.oersteds and a coercivity of 4·8 kilo-oersteds. Applications are mentioned.

538.222 : 538.569.4 : 621.375.9 **3472**

**On the Harmonic Spin Coupling in Dilute Paramagnetic Systems.**—M. Hirono. (*J. Radio Res. Labs, Japan*, Jan. 1962, Vol. 9, No. 41, pp. 73–84.) The process of harmonic spin coupling of three neighbouring ions is examined by the moment method on the basis of the theory proposed by Bloembergen et al. (3270 of 1959). See also 4239 of 1961.

539.23 : 621.382 **3473**

**Electrode Effects on Aluminium Oxide Tunnel Junctions.**—R. M. Handy. (*Phys. Rev.*, 15th June 1962, Vol. 126, No. 6, pp. 1968–1973.) The properties of evaporated Al-$Al_2O_3$-$M_x$ tunnel junctions have been investigated for $M_x$ = Ni, Cu, Al, Ag, Au, Sn, Sb, Pb and Bi. Relative tunnel resistance increases with atom size up to an atomic radius of approximately 1·6 Å.

539.232 : 533.5 **3474**

**A Control System for the Evaporation of Silicon Monoxide Insulating Films.**—R. E. Hayes & A. R. V. Roberts. (*J. sci. Instrum.*, Aug. 1962, Vol. 39, No. 8, pp. 428–431.) A control system is described based on continuous measurement of the vapour stream momentum, and a periodic measurement of deposit weight.

548.5 **3475**

**The Conditions for Growth in the Czochralski Method.**—D. Geist & P. Grosse. (*Z. angew. Phys.*, Feb. 1962, Vol. 14, No. 2, pp. 105–108.) The mechanism of the method is investigated and from consideration of the heat balance the conditions for static crystal growth are derived.

66.049.1 : 539.232 **3476**

**Simple Method of Registering Evaporation Masks.**—G. W. Leck. (*Rev. sci. Instrum.*, June 1962, Vol. 33, No. 6, pp. 683–684.) A photographic technique is described for determining the adjustment required to bring superimposed marks in register. An ultraviolet light source is used in place of the basket containing the material to be evaporated, and a light-sensitive substrate in place of the actual substrate to be used.

## MATHEMATICS

51 : 003.62 **3477**

**French Pronunciation of Mathematical Formulae.**—S. Wolff. (*Elektronische Rundschau*, June 1962, Vol. 16, No. 6, pp. 266–272.) 118 mathematical symbols and examples of their application are tabulated and their oral rendering in French is given.

517.513 : 621.3.018.783 **3478**

**A Contribution to the Theory of Nonlinear Processes.**—E. Augustin. (*Tech. Mitt. RFZ, Berlin*, June 1962, Vol. 6, No. 2, pp. 51–58.) Mathematical methods for the calculation of signal distortion and modulation effects due to nonlinear characteristics are presented.

## MEASUREMENTS AND TEST GEAR

621.3.018.41(083.74) **3479**

**An International Experiment in Frequency Comparison.**—R. L. Corke. (*P.O. elect. Engrs' J.*, July 1962, Vol. 55, Part 2, pp. 80–82.) A comparison was made of the phase of signals from the 16-kc/s transmitter at Rugby received at Banbury, England, and Cambridge, Mass. In the measurement of frequency, an accuracy of 2 parts in $10^{11}$ can be expected for a 24-h period of measurement.

621.317.332 **3480**

**Generalized Bridged-T Configuration.**—K. Posel. (*Electronic Technol.*, Aug. 1962, Vol. 39, No. 8, pp. 307–313.) From the parallel-T network a generalized bridged-T configuration is derived which is advantageous for measuring inductive impedance.

621.317.34 : 621.372.824 **3481**

**Application of Reflectometer Techniques to Accurate Reflection Measurements in Coaxial Systems.**—R. W. Beatty & W. J. Anson. (*Proc. Instn elect. Engrs*, Part B, July 1962, Vol. 109, No. 46, pp. 345–348.) Detailed discussion of theory and equipment using a single directional-coupler reflectometer with two auxiliary tuners. The results of measurements of the reflections from connectors and various loads at 4 Gc/s are given.

621.317.361 : 621.376.332 **3482**

**Frequency Measurement with a Discriminator.**—G. Kosel. (*Arch. elekt. Übertragung*, July 1962, Vol. 16, No. 7, pp. 359–363.) The operation of the frequency discriminator described is based on the principle of the coincidence of two pulse trains of the same repetition frequency which are delayed with respect to each other. Design equations are derived and the influence of noise interference is investigated.

621.317.44 : 538.632 **3483**

**Very-Low-Offset Hall Probe.**—H. Roth & W. D. Straub. (*J. appl. Phys.*, July 1962, Vol. 33, No. 7, p. 2397.) A circuit is described which reduces the offset effect due to misalignment of the Hall contacts to negligible proportions.

621.317.733.029.62/.63 **3484**

**Amplitude and Phase Measurement in the V.H.F. Region.**—B. M. Thomas. (*Electronic Engng*, Aug. 1962, Vol. 34, No. 414, pp. 546–548.) A commercial v.h.f. impedance bridge is used to measure changes of amplitude and phase in a network in the frequency range 100–500 Mc/s.

621.317.79.029.64 **3485**

**Absolute Microwave Refractometer.**—M. J. Vetter & M. C. Thompson, Jr. (*Rev. sci. Instrum.*, June 1962, Vol. 33, No. 6, pp. 656–660.) A calibrated servo-controlled tunable cavity resonator is made to follow the variations in the resonant frequency of the sampling resonator.

## OTHER APPLICATIONS OF RADIO AND ELECTRONICS

535.376.07 **3486**

**Nonlinear Resistors Enhance Display-Panel Contrast.**—H. G. Blank, J. A. O'Connell & M. S. Wasserman. (*Electronics*, 3rd Aug. 1962, Vol. 35, No. 31, pp. 33–36.) By the addition of a nonlinear resistive layer between the electroluminescent phosphor and the electrodes the brightness discrimination factor between full and half voltage becomes more than 10 000 : 1. This is more than enough to eliminate cross-image effects observed in earlier designs.

621.383.8 **3487**

**The Application of Boundary-Layer Light Control for Image Conversion and Image Intensification.**—H. Nassenstein. (*Z. angew. Phys.*, Feb. 1962, Vol. 14, No. 2, pp. 108–115.) The design and operation of an image converter and intensifier are described in which light control is achieved by means of refractive-index changes in a liquid. Results obtained with an experimental arrangement are discussed.

621.385.833 **3488**

**The Image Characteristics of the Field in Front of a Magnetic Objective with Glaser-Type Bell-Shaped Field.**—W. D. Riecke. (*Optik, Stuttgart*, March & April 1962, Vol. 19, Nos. 3 & 4, pp. 169–183 & 193–207.)

621.387.4 : 621.383.292 **3489**

**A Stepless Secondary-Electron Multiplier.**—H. Hamisch. (*Z. angew. Phys.*, May 1962, Vol. 14, No. 5, pp. 322–324.) A semiconductor surface is used instead of a dynode structure. The advantage of this device over that described by Goodrich & Wiley (4270 of 1961) lies in the absence of a magnetic field, which simplifies the construction.

656.11 : 621.396.969.14 **3490**

**Analysis of Road Traffic by means of Radar.**—K. Röhrich. (*VDI Z.*, 11th May 1962, Vol. 104, No. 14, pp. 617–623.) The use of radar detectors for counting road users, and the operation and design of traffic analysers are discussed. The latter provide a record of speed distribution and are capable of distinguishing the types of vehicle.

## PROPAGATION OF WAVES

621.391.812.62 **3491**

**Defocusing of Radio Rays by the Troposphere.**—R. E. Wilkerson. (*J. Res. nat. Bur. Stand.*, July/Aug. 1962, Vol. 66D, No. 4, pp. 479–485.) General formulae are derived for the divergence coefficients of the direct and reflected rays passing through the atmosphere, assuming a smooth spherical earth.

621.391.812.62/.63 : 551.507.362 **3492**

**Propagation Problems with Space Radio Communications.**—K. Rawer. (*J. Res. nat. Bur. Stand.*, July/Aug. 1962, Vol. 66D, No. 4, pp. 375–393.) Ionospheric and tropospheric refraction and absorption affect propagation between earth and space, the relative importance of the ionosphere being considerably larger than for terrestrial propagation. The most important tropospheric effects are molecular absorption and the corresponding statistical noise. About 140 references.

621.391.812.62.029.62/.64 **3493**

**Propagation Influence in Microwave Link Operation.**—M. W. Gough. (*J. Brit. Instn Radio Engrs*, July 1962, Vol. 24, No. 1, pp. 53–72.) An analysis of certain microwave measurements selected to illustrate propagation phenomena peculiar to radio links and to throw light on the fundamental processes of microwave propagation.

621.391.812.63 **3494**

**On the Forward Scattering of Radio Waves in the Lower Ionosphere.**—T. Hagfors. (*J. Res. nat. Bur. Stand.*, July/Aug. 1962, Vol. 66D, No. 4, pp. 409–418.) Operational results obtained at 46·8 Mc/s over a 1 180-km path in Norway are summarized. Forward scattering is explained by two simultaneous propagation modes, one from meteor trails at about 100 km and the other by turbulence in the neutral air at about 80–85 km.

621.391.812.63 : 551.510.535 **3495**

**Ionospheric Equivalent Heights of Reflection Calculated by a Full-Wave Method and by the Phase-Integral Method.**—K. G. Budden & E. Cooper. (*J. atmos. terr. Phys.*, July 1962, Vol. 24, pp. 609–618.) Good agreement is obtained for radio waves incident normally on a Chapman layer. The sharp edges of a parabolic layer upset the results of the phase-integral method [267 of January (Cooper)].

621.391.812.63 : 621.396.933.2 : 529.786 **3496**

**Phase Measurements of C.W. Transmissions at 80 kc/s over a 1 900-km Path.**

—J. S. Belrose. (*Proc. Inst. Radio Engrs*, July 1962, Vol. 50, No. 7, p. 1713.) Measurements made in November 1960 to study the lower ionosphere at high latitudes do not entirely agree with observations made by Doherty et al. (530 of February).

621.391.812.63.029.45/.51 **3497**

**Ionospheric Reflection Processes for Long Radio Waves: Part 2.**—B. S. Westcott. (*J. atmos. terr. Phys.*, July 1962, Vol. 24, pp. 619–631.) Formulae derived in Part 1 (2802 of August) for vertically incident waves are extended to the case of oblique incidence, using the same isotropic ionospheric model, in which electron density increases exponentially with height. Results for vertical and horizontal polarization are calculated for frequencies from 8 to 128 kc/s, and the effect of varying the collision frequency is studied.

621.391.812.63.029.45 **3498**

**Introduction to the Theory of V.L.F. Propagation.**—J. R. Wait. (*Proc. Inst. Radio Engrs*, July 1962, Vol. 50, No. 7, pp. 1624–1647.) A review of the theory including both geometric and waveguide approaches. Certain simplifying assumptions enable results obtained to be compared with experiment.

621.391.812.63.029.45 **3499**

**An Analysis of V.L.F.-Mode Propagation for a Variable Ionosphere Height.**—J. R. Wait. (*J. Res. nat. Bur. Stand.*, July/Aug. 1962, Vol. 66D, No. 4, pp. 453–461.) The model suggested for the analysis consists of two parallel-plate waveguide regions connected by a linearly tapered section.

621.391.812.63.029.45 **3500**

**Diurnal Variation of the Propagation Time of Very-Low-Frequency Waves.**—B. Decaux & A. Gabry. (*C. R. Acad. Sci., Paris*, 10th April 1961, Vol. 252, No. 15, pp. 2187–2189.) Continuous recordings of the phase of signals received from Rugby (GBR) and Panama (NBA) show variations between day and night which are a function of the distance to these transmitters.

621.391.814.2.029.4/.5 **3501**

**Effect of Ridge, Cliff and Bluff at Coastal Line on Ground Radio Waves.**—K. Furutsu. (*J. Radio Res. Labs, Japan*, Jan. 1962, Vol. 9, No. 41, pp. 85–122.) Results are displayed in sets of charts for medium and low frequencies and a wide range of parameters. As expected, a ridge on lossy ground gives an obstacle gain even though the ground is a plane, when the Sommerfeld numerical distance from the ridge is sufficiently large.

## RECEPTION

621.376: 621.391.822 **3502**

**The Influence of Averaging on the Effectiveness of Correlation Detectors.**—G. Winkler. (*Arch. elekt. Übertragung*, July 1962, Vol. 16, No. 7, pp. 347–350.) Averaging by means of an ideal integrator with finite integration time makes better use of the available operating time than a low-pass filter in a steady-state condition. Optimum signal/noise ratio can, however, be obtained if the time constant of the low-pass filter is of the order of the operating time.

621.391.81 **3503**

**Field-Strength Measurements Within the Service Area of the V.H.F. Broadcast and Television Transmitters in the D.D.R. [German Democratic Republic].**—U. Kühn & J. Käbe. (*Tech. Mitt. RFZ, Berlin*, June 1962, Vol. 6, No. 2, pp. 81–84.) The measurements were carried out by means of continuous recordings in a moving vehicle using an aerial of 3-m height.

621.391.812.61.029.65 **3504**

**Statistical Fluctuation of Amplitude and Phase of Radio Signals Passing through the Rain.**—T. Oguchi. (*J. Radio Res. Labs, Japan*, Jan. 1962, Vol. 9, No. 41, pp. 51–72.) A theoretical treatment of the problem of signal fluctuation of wide-band signals at mm λ transmitted through rain. The problem is discussed in terms of a single-frequency transmission. Under normal conditions a very small fluctuation is expected to occur.

621.391.812.624.029.63: 621.396.666 **3505**

**Antenna-Beam Deflection Loss and Signal Amplitude Correlation in Angle-Diversity Reception in U.H.F. Beyond-Horizon Communications.**—T. Koono, M. Hirai, R. Inoue & Y. Ishizawa. (*J. Radio Res. Labs, Japan*, Jan. 1962, Vol. 9, No. 41, pp. 21–49.) The loss due to the deflection of the antenna beam, and the amplitude correlation between signals received by an angle-diversity method for u.h.f. beyond-horizon communication, have been investigated theoretically and experimentally. Fairly good agreement has been found between the experimental and theoretical results.

621.396.621: 621.375.9 **3506**

**Noise Degradation resulting from Superregenerative Operation.**—H. Helfner. (*J. Electronics Control*, June 1962, Vol. 12, No. 6, pp. 501–504.) A note on the importance of distinguishing between the r.f. bandwidth and modulation bandwidth in considering the noise figure of a superregenerative amplifier [e.g. 1497 of May (Jordan & Elco)].

621.396.621.54 **3507**

**Spurious Responses in Superheterodyne Receivers.**—J. H. Lepoff. (*Microwave J.*, June 1962, Vol. 5, No. 6, pp. 95–98.) An examination of methods of avoiding spurious responses in panoramic receivers due to intermodulation of harmonics of the signal and the local oscillator frequency.

621.396.666 **3508**

**A Diversity Combiner giving Total Power Transfer.**—J. M. Sidwell. (*Proc. Instn elect. Engrs*, Part B, July 1962, Vol. 109, No. 46, pp. 305–309. Discussion.) A combining system in which the output signal power is always the sum of the individual powers, giving optimum signal/noise ratio under Rayleigh fading conditions.

621.396.666: 621.391.812 **3509**

**Diversity Reception and Automatic Phase Correction.**—L. Lewin. (*Proc. Instn elect. Engrs*, Part B, July 1962, Vol. 109, No. 46, pp. 295–304. Discussion, pp. 309–310.) Interference patterns and optimum heights are discussed. An automatic phasing network is used for combining signals from two microwave diversity mirrors. Results for a 69-mile over-water link at 4 Gc/s show improved fading characteristics compared with switching systems.

## STATIONS AND COMMUNICATION SYSTEMS

621.376.3: 621.396.96 **3510**

**A Property of Linear Frequency Modulation.**—A. J. Goldman. (*Proc. Inst. Radio Engrs*, July 1962, Vol. 50, No. 7, p. 1711.) A linear f.m. signal when passed through a suitable network with linear delay possesses certain characteristics useful with chirp radars. No other f.m. signal and delay network are related in this way.

621.391: 621.397.23 **3511**

**Contribution on the Transmission or Recording of a Wide Signal Band.**—A. M. Springer. (*Elektronische Rundschau*, June 1962, Vol. 16, No. 6, pp. 259–260.) Methods for transmitting television signals via telephone channels are summarized. Frequency-band splitting and transposition by means of filters or electronic scanning and storage devices are mentioned.

621.391.63 **3512**

**Project Luna See.**—L. D. Smullin & G. Fiocco. (*Proc. Inst. Radio Engrs*, July 1962, Vol. 50, No. 7, pp. 1703–1704.) The radiation from a ruby laser was focused on the moon to give an effective point source when viewed from the earth. There was evidence that reflected waves were just detectable.

621.396.43: 551.507.362.2 **3513**

**The Tasks of the C.C.I.R. and of its Study Group IV in the Field of Telecommunications by means of Artificial Earth Satellites.**—W. Klein. (*Tech. Mitt. PTT*, July 1962, Vol. 40, No. 7, pp. 228–233. In German and French.)

621.396.43: 551.507.362.2 **3514**

**Satellite Communication Systems.**—W. J. Bray. (*P.O. elect. Engrs' J.*, July 1962, Vol. 55, Part 2, pp. 97–104.) The characteristics and potentialities of satellite communication systems, and the types of satellites and satellite orbits which could be used, are considered.

621.396.43: 551.507.362.2 **3515**

**Equipment and Testing Facilities at the Experimental Satellite Ground Station, Goonhilly Downs, Cornwall.**—F. J. D. Taylor. (*P.O. elect. Engrs' J.*, July 1962, Vol. 55, Part 2, pp. 105–112.) An outline is given of the equipment provided, some of its special features and the tests to be made with it as part of projects Relay and Telstar.

621.396.43 : 551.507.362.2 **3516**

**The Post Office Satellite System Ground Station at Goonhilly Downs.**—W. J. Bray & F. J. D. Taylor. (*Brit. Commun. Electronics*, Aug. 1962, Vol. 9, No. 8, pp. 574–579.) A general description of the station, its equipment and the facilities available.

621.396.43 : 551.507.362.2 **3517**

**The Andover Ground Station for Project Telstar.**—(*Brit. Commun. Electronics*, Aug. 1962, Vol. 9, No. 8, pp. 580–581.) A brief description of the American ground equipment developed for use with communication satellites.

621.396.43 : 551.507.362.2 **3518**

**Project Relay.**—R. E. Warren & J. R. Burke. (*Brit. Commun. Electronics*, Aug. 1962, Vol. 9, No. 8, pp. 582–583.) A description and operational data are given for the communication satellite developed by the National Aeronautics and Space Administration.

621.396.44 : 621.372.8 **3519**

**System Aspects of Long-Distance Communication by Waveguide.**—Karbowiak. (See 3235.)

621.396.65.029.64 **3520**

**The Radio Link System FM 120/7 000, Transmission Equipment for 120 Speech Circuits in the Microwave Range: Bases of Design and Results of Measurements.**—P. Maurer, E. Seibt & C. Colani. (*Frequenz*, June 1962, Vol. 16, No. 6, pp. 201–207.) Description of a 7-Gc/s radio-link installation. See 2816 of August (Willwacher).

621.396.71 **3521**

**Museum Radio Tower.**—H. Knee & F. G. Balcombe. (*P.O. elect. Engrs' J.*, July 1962, Vol. 55, Part 2, pp. 73–79.) A detailed description of the facilities to be provided by the 600-ft radio tower under construction in London.

621.396.721 + 621.397.721 **3522**

**Apparatus for Television and Sound Relay Stations: Translators, Receivers and Drive Equipment.**—F. A. Peachey, R. Toombs & D. L. Smart. (*B.B.C. Engng Div. Monographs*, July 1962, No. 42, pp. 5–22.) New equipment for relay stations is described which has been developed since the original plan [621 of 1958 (Wynn & Peachey)].

621.396.933 : 621.391.812.63 **3523**

**Frequency Sounding Techniques for H.F. Communications over Auroral-Zone Paths.**—G. W. Jull, D. J. Doyle, G. W. Irvine & J. P. Murray. (*Proc. Inst. Radio Engrs*, July 1962, Vol. 50, No. 7, pp. 1676–1682.) An investigation of the use o frequency sounding techniques as a means of sampling a sequence of communication channels in order to ascertain the optimum frequencies under conditions of short-term ionospheric disturbances in auroral regions. Ground-to-air trials during geomagnetic storms are reported.

## SUBSIDIARY APPARATUS

621.314.63 : 621.316.8 **3524**

**The Efficiency of Bulk Rectification.**—A. K. Kamal & W. L. Adams. (*Proc. Inst. Radio Engrs*, July 1962, Vol. 50, No. 7, pp. 1684–1686.) An investigation of the potentialities of pseudo-rectification [see 145 of 1961 (Bridges)]. Efficiencies of about 15% at unlimited power might be attainable at u.h.f.

681.846 : 621.397 **3525**

**Electronic Editing of Magnetic Television Tape Recordings.**—N. F. Bounsall. (*J. Soc. Mot. Pict. Telev. Engrs*, Feb. 1962, Vol. 71, No. 2, pp. 95–99.) The operating procedure and components of an electronic video-tape editing system are described. A master tape is produced with instantaneous change of picture content but without overlap or loss of information. An account of this equipment is also given in *Wireless World*, Sept. 1962, Vol. 68, No. 9, pp. 404–408.

## TELEVISION AND PHOTOTELEGRAPHY

621.397.132 **3526**

**Investigation of a Colour Television Method with Simultaneous Frequency- and Amplitude-Modulation of a Chrominance Subcarrier Lying in the Frequency Range of the Luminance Signal (F.A.M. Method).**—N. Mayer. (*Rundfunktech. Mitt.*, May 1962, Vol. 6, No. 3, pp. 125–143.) The method described, although simpler than the N.T.S.C. system, is shown to produce results of comparable quality. See also 3161 of 1961.

621.397.23 **3527**

**Tests of Three Systems of Bandwidth Compression of Television Signals.**—G. F. Newell & W. K. E. Geddes. (*Proc. Instn elect. Engrs*, Part B, July 1962, Vol. 109, No. 46, pp. 311–323. Discussion.) In each method the essential brightness changes are isolated and redistributed to occur at a uniform transmission rate. Because of inferior reproduction quality none of the three methods is considered worthwhile at present.

621.397.331.222 **3528**

**The Development of a Vidicon Camera Tube with Enlarged Photocathode (2-in. Diameter).**—W. Heimann. (*Rundfunktech. Mitt.*, May 1962, Vol. 6, No. 3, pp. 111–113.) Performance data of the new tube are compared with those of the 1-in. vidicon. A considerable improvement in resolution has been achieved.

621.397.331.222 **3529**

**The Present-Day Limits of Efficiency of Vidicons.**—W. Dillenburger. (*Elektronische Rundschau*, May 1962, Vol. 16, No. 5, pp. 205–211.) Various aspects of vidicon performance are reviewed. The operation of a 1-in. tube at 800–1 000 V gives satisfactory results under most conditions.

621.397.61 **3530**

**Design Problems of Modern Television Transmitters.**—W. Roos. (*Electronics*, 20th July 1962, Vol. 35, No. 29, pp. 53–54.) By incorporating the residual-sideband filter in the band-pass filter that forms the anode load for the transmitter output stage, considerable space can be saved.

621.397.611 : 681.42.089 **3531**

**The Investigation of Lenses for Television.**—W. N. Sproson. (*Rundfunktech. Mitt.*, May 1962, Vol. 6, No. 3, pp. 97–101.) Test equipment and methods are described.

621.397.621 : 621.382.3 **3532**

**Television Line Time-Base Output Stages using Transistors.**—K. E. Martin. (*J. Brit. Instn Radio Engrs*, July 1962, Vol. 24, No. 1, pp. 7–20.) The peak VA products to be handled by the line output transistor and efficiency diode for different picture tubes are considered. Aspects of circuit design are discussed and a complete design is given of the output stage for a 90° tube operating at 12 kV.

621.397.63 : 621.395.625.3 **3533**

**The Foil Storage-Device, a Means of Recording Television Signals.**—C. Bodenstein & R. Otto. (*Rundfunktech. Mitt.*, May 1962, Vol. 6, No. 3, pp. 102–105.) In the recording device described a flexible disk with magnetic coating is supported by a film of air [see 1315 of 1961 (Pearson)]. A number of still pictures can be stored on several tracks.

621.397.63 : 621.395.625.3 **3534**

**The Recording and Reproduction of Still Pictures by means of the Foil Storage Device.**—H. G. Walther. (*Rundfunktech. Mitt.*, May 1962, Vol. 6, No. 3, pp. 106–110.) Description of the complete recording installation incorporating the magnetic disk detailed in 3533 above. Performance characteristics are discussed.

621.397.7 **3535**

**External Synchronization of the Portable Outside-Broadcast Camera.**—E. Legler. (*Rundfunktech. Mitt.*, May 1962, Vol. 6, No. 3, pp. 114–117.) A new version of the outside-broadcast equipment detailed in 353 of 1961 is described in which the camera is synchronized by a radio signal transmitted from the outside-broadcast vehicle.

621.397.74 : 621.396.65 : 621.391.826 **3536**

**Echo Suppression in Television Cable Links by means of Low-Attenuation Passive Quadripoles.**—R. Rasch. (*Nachrichtentech. Z.*, June 1962, Vol. 15, No. 6, pp. 267–278.) The design and construction of various passive echo equalizers with negligible insertion loss and mismatch are described. Design formulae are tabulated.

621.397.743 **3537**

**Quality Supervision in the Service Area of the Südwestfunk.**—K. H. Baer. (*Rundfunktech. Mitt.*, May 1962, Vol. 6, No. 3, pp. 118–124.) A system of assessing the overall quality of the television signal within the entire transmission network is described. A test signal is transmitted at regular intervals from the studio centre and oscillograms obtained at various points in the chain are recorded and analysed. A comparison between 1958 and 1961 performance data is included.

## TRANSMISSION

621.396.61 : 621.396.43 : 551.507.362.2 **3538**

**The 1 700-Mc/s Transmitter.**—E. A. Rattue & D. L. Cooper-Jones. (*Brit. Commun. Electronics*, Aug. 1962, Vol. 9, No. 8, pp. 587–589.) A description of the transmitter for use at Goonhilly Downs in Project Relay. A maximum output power at 10 kW with a 15·5-Mc/s bandwidth to 0·5-db points is produced.

621.396.61 : 621.396.43 : 551.507.362.2 **3539**

**The Output Stage for the Ground Transmitter for Project Telstar.**—A. R. Petheram. (*Brit. Commun. Electronics*, Aug. 1962, Vol. 9, No. 8, pp. 592–594.) The output stage delivers 4 kW at 6 390 Mc/s with a bandwidth of about 100 Mc/s.

621.396.61.029.62 : 621.376.32 **3540**

**A Fully Transistorized Frequency Modulator for V.H.F. and Television Sound Transmitters.**—G. Juhre. (*Tech. Mitt. RFZ, Berlin*, June 1962, Vol. 6, No. 2, pp. 59–66.) Problems arising from the conversion of a valve circuit to one using transistors are discussed. The design of a master oscillator is described and performance data are given.

621.396.74 **3541**

**Decoupling Bridge Circuits for Parallel Connection of Transmitters in the Medium- and Long-Wave Bands.**—W. Buschbeck. (*Nachrichtentech. Z.*, May 1962, Vol. 15, No. 5, pp. 223–231.) Detailed discussion of the characteristics of various λ/4 bridge networks. For bridge circuits used in the short-wave and v.h.f. bands see 3170 of September (Buschbeck & Burkhardtsmaier).

## VALVES AND THERMIONICS

621.382 **3542**

**Current Gain in Metal/Interface Amplifiers.**—J. M. Lavine & A. A. Iannini. (*Proc. Inst. Radio Engrs*, July 1962, Vol. 50, No. 7, pp. 1688–1689.) Experiments are described which strongly support a proposal made by Hall (2475 of July) that the dominant current transfer mechanism in metal/interface amplifiers is direct injection into the space-charge region.

621.382.23 **3543**

**Experimental Verification of the Price-Radcliffe-Kane Tunnelling Equation.**—W. N. Carr. (*Proc. Inst. Radio Engrs*, July 1962, Vol. 50, No. 7, p. 1705.) Data obtained from a series of experiments with tunnel diodes are compared with the characteristics predicted by the theories of Esaki (1784 of 1958) on the one hand, and of Price & Radcliffe (2926 of 1960) and Kane (1554 of 1961) on the other. Results are more favourable to the latter.

621.382.23 **3544**

**Germanium and Silicon High-Frequency Esaki Diodes.**—C. A. Burrus. (*Proc. Inst. Radio Engrs*, July 1962, Vol. 50, No. 7, pp. 1689–1690.) A note on the fabrication of Ge and Si Esaki diodes which have been observed to oscillate respectively in the 4–5 and 6–7 mm λ region.

621.382.23 **3545**

**X-Band Operation of S-Band Esaki Diodes.**—K. Ishii & C. C. Hoffins. (*Proc. Inst. Radio Engrs*, July 1962, Vol. 50, No. 7, pp. 1698–1699.) Experimental results showing stable operation are reported.

621.382.23 : 546.681'19 **3546**

**Structure in the Excess Current Region of Gallium Arsenide Tunnel Diodes.**—R. W. Hamaker & H. F. Quinn. (*J. appl. Phys.*, July 1962, Vol. 33, No. 7, pp. 2396–2397.) 'Secondary tunnelling effects' due to doping of GaAs tunnel diodes with Si, Ge, Sn and Pb are illustrated.

621.382.23 : 621.316.722.1 **3547**

**Remarks on the Stabilization Characteristics of Zener Diodes.**—H. J. Stöhr. (*Elektronische Rundschau*, July 1962, Vol. 16, No. 7, pp. 297–301.) An equivalent circuit is derived which takes account of the thermal properties of the Zener diode. In the design of stabilizing circuits allowance must be made for these thermal parameters.

621.382.23 : 621.317.331 **3548**

**Technique for Measuring Tunnel-Diode Series Resistance.**—R. F. Wilfinger & B. A. Zolotar. (*Rev. sci. Instrum.*, June 1962, Vol. 33, No. 6, pp. 693–694.) A simple technique giving a resolution of ± 0·001 Ω.

621.382.23 : 621.374.4 **3549**

**Harmonic Generation, Rectification, and Lifetime Evaluation with the Step Recovery Diode.**—S. M. Krakauer. (*Proc. Inst. Radio Engrs*, July 1962, Vol. 50, No. 7, pp. 1665–1676.) A circuit based on a *p-n*-junction diode which switches very abruptly from reverse storage conduction to cut-off is described. Its application to the generation of waveforms rich in high-order harmonics is discussed. A general expression for rectification efficiency applicable to any semiconductor diode is derived.

621.382.3 **3550**

**Fluctuations of the Transistor Barrier-Layer Temperature under Periodic-Drive Conditions.**—F. Weitzsch. (*Arch. elekt. Übertragung*, July 1962, Vol. 16, No. 7, pp. 335–342.) The barrier-layer temperature is calculated for (*a*) the periodic square-wave variation of dissipated power with superimposed transient losses due to transistor switching, and (*b*) constant dissipated power with superimposed sinusoidal variations of power.

621.382.333 **3551**

**Theory of Transistors for Use at High Frequencies.**—E. Fröschle. (*Z. angew. Phys.*, May 1962, Vol. 14, No. 5, pp. 288–297.) The dependence of the small-signal parameters on the design data of modern junction transistors for high-frequency applications, e.g. the mesa type, is investigated.

621.383.29 : 621.391.63 **3552**

**The Microwave Phototube—New Detector for Optical Receivers.**—R. G. E. Hutter. (*Electronics*, 20th July 1962, Vol. 35, No. 29, pp. 37–41.) The operation of the device as a microwave modulation detector and as a mixer of modulated and unmodulated laser light beams is described.

621.385.632 **3553**

**The Five-Kilowatt Travelling-Wave Tube.**—M. O. Bryant. (*Brit. Commun. Electronics*, Aug. 1962, Vol. 9, No. 8, pp. 590–591.) The 5-kW c.w. travelling-wave amplifier used in the output stage of the Telstar ground transmitter at Goonhilly Downs (see 3538 above) has a clover-leaf slow-wave structure. It is tunable from 6 275 Mc/s to 6 550 Mc/s and has a bandwidth of ± 25 Mc/s at the 0·5-db points.

621.385.632 **3554**

**Travelling-Wave Tube with 1·7-db Noise Figure in L Band.**—B. P. Israelsen & R. W. Peter. (*Proc. Inst. Radio Engrs*, July 1962, Vol. 50, No. 7, p. 1683.) The low noise figure was achieved by refrigeration with liquid nitrogen.

## MISCELLANEOUS

621.316.7 : 62-53 **3555**

**Control Engineering.**—M. Thoma. (*VDI Z.*, 11th July 1962, Vol. 104, No. 20, pp. 917–930.) Annual review covering recent developments in control systems, equipment and applications. 443 references.

621.391 + 534.86](083.3) **3556**

**Does 1 N equal 8·6858 db, and is it Permissible to Attach Suffixes to db?**—W. Reichardt. (*Frequenz*, March 1962, Vol. 16, No. 3, pp. 97–102.) The questions are answered in the affirmative. N and db are treated as factors permitting the conversion between different forms of logarithm. The use of suffixes is justified but it would be preferable to write, e.g. db re 1 mW instead of dbm.

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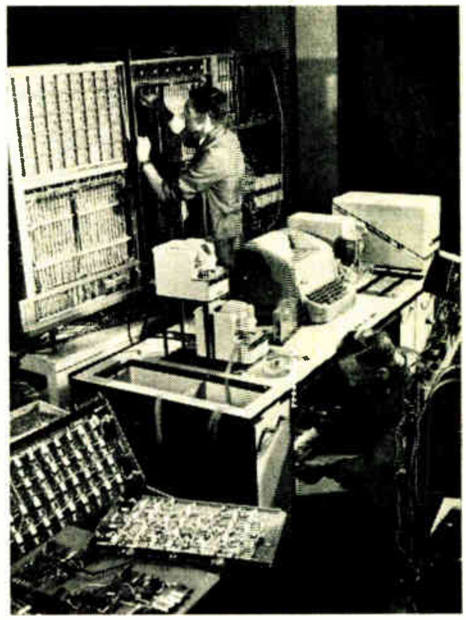
## FEATURES





**OUR COVER**

*This illustrates the final stages of assembly of a National-Elliott 803 General Purpose Digital Computer. Elsewhere in this issue the application of the Elliott articulated computer hierarchy (Arch) to the automation of paper-box production is discussed*

## Next Month

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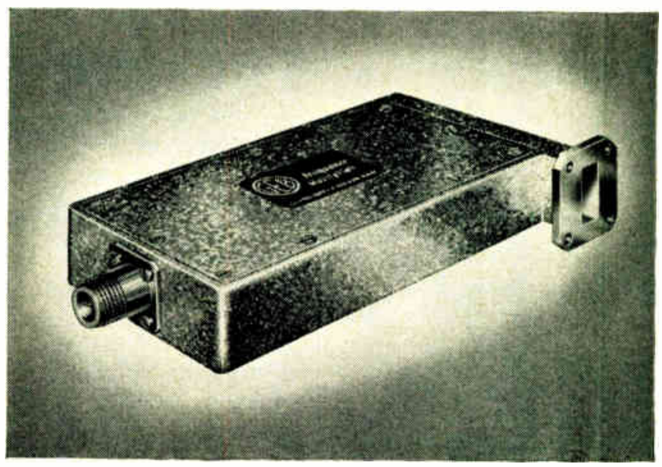

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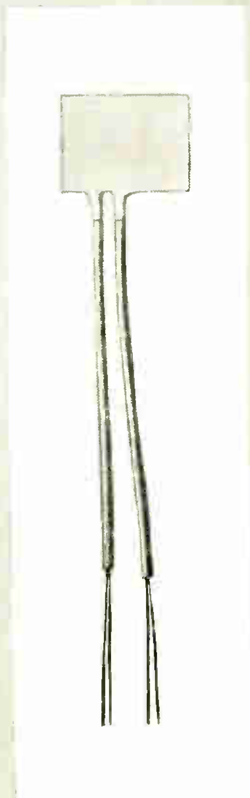

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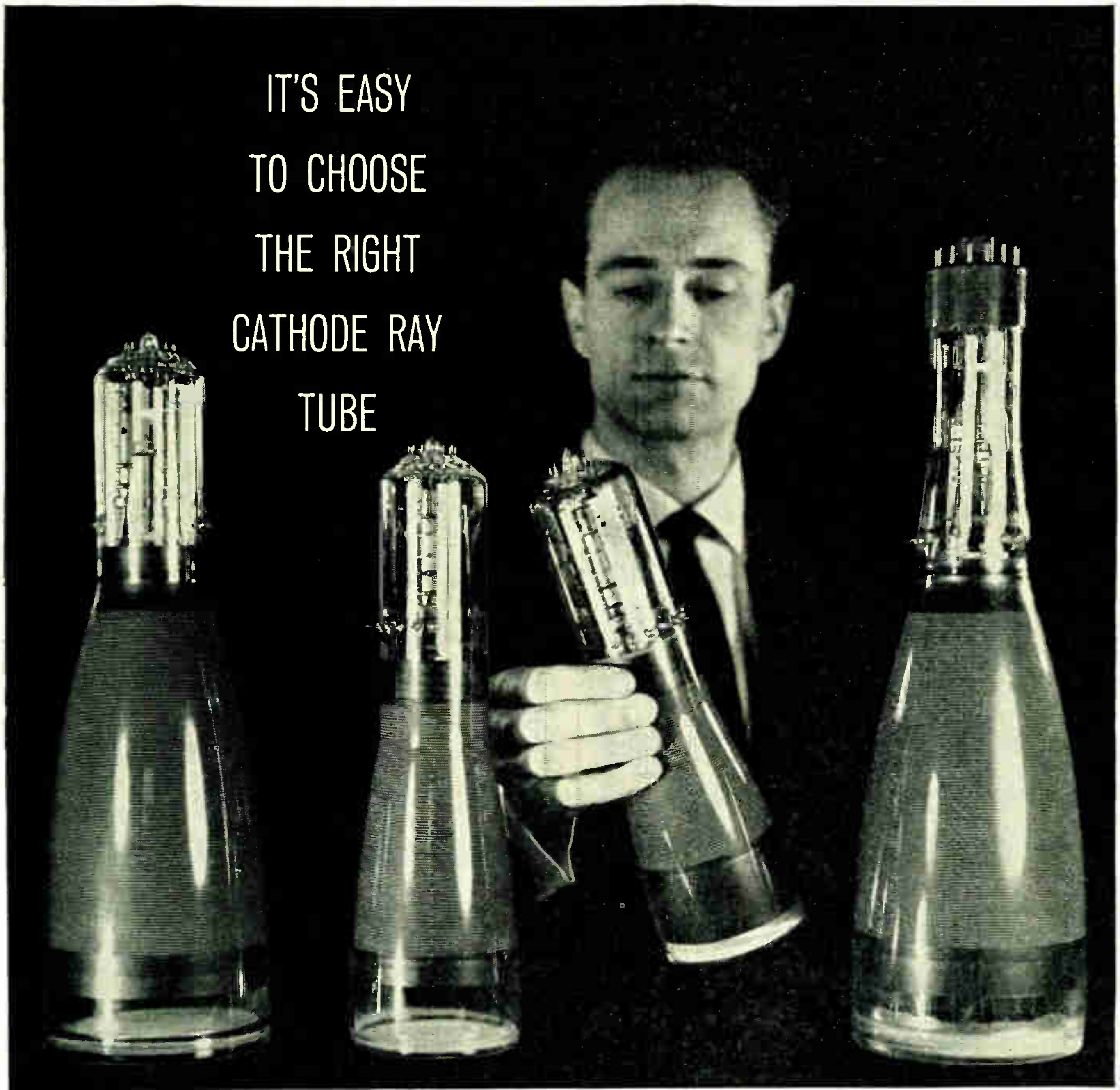


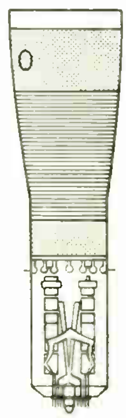

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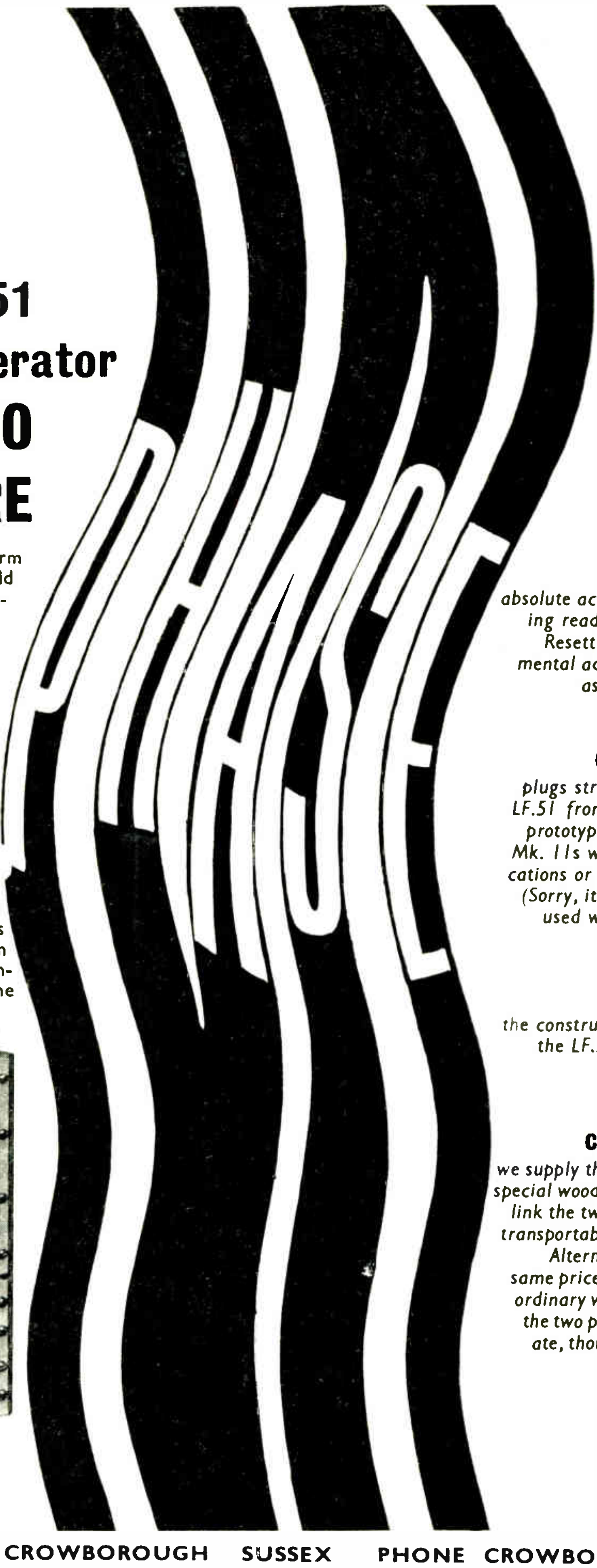


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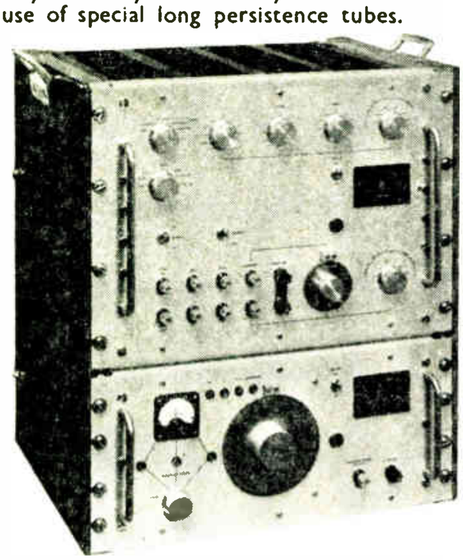

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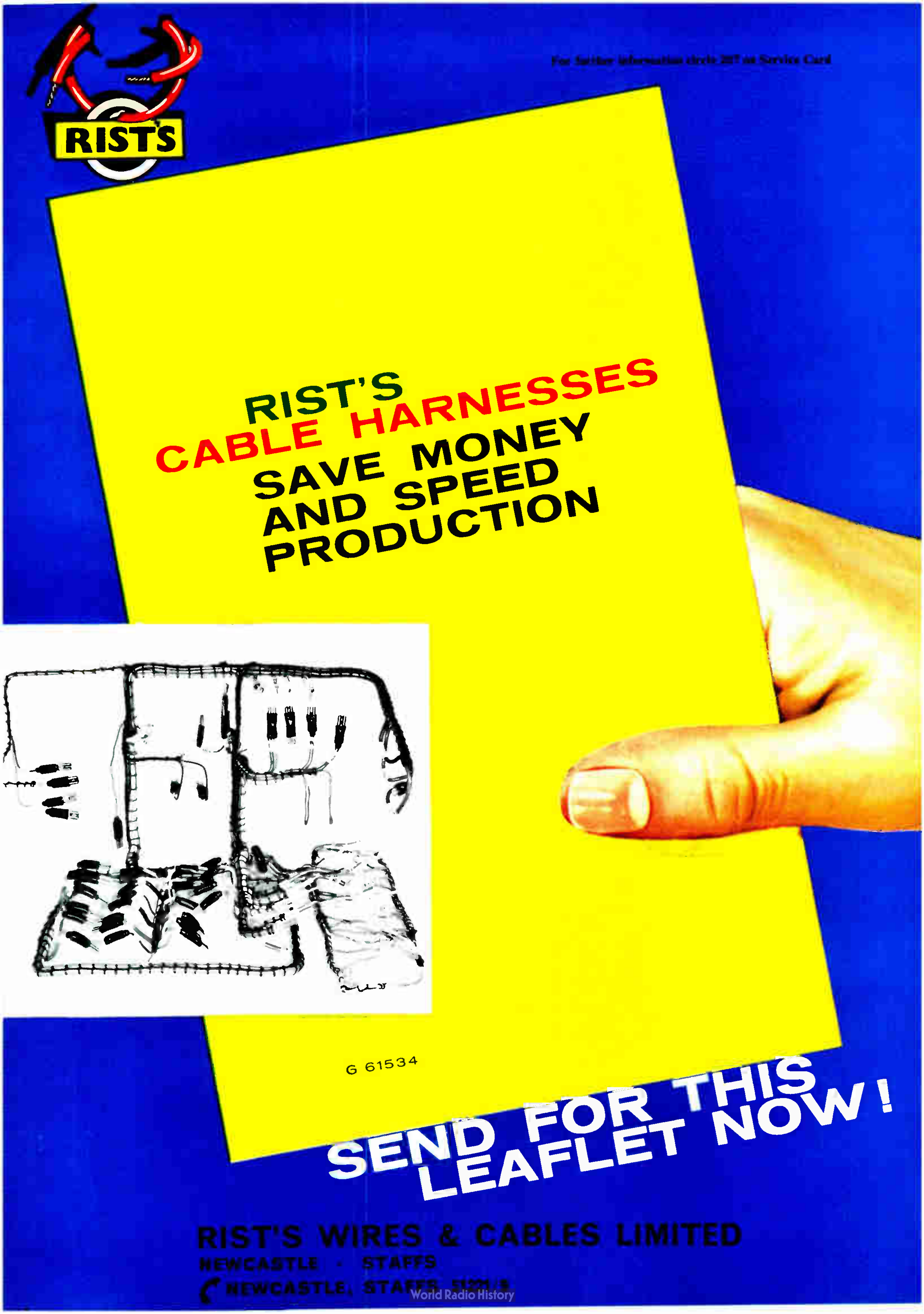
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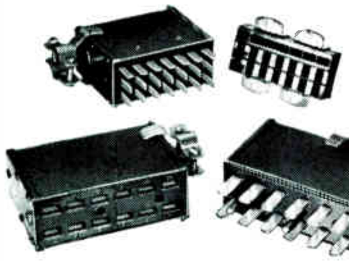

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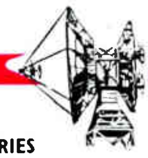

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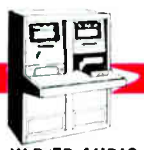

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  2 to 18 contacts. (EP series).
  3, 4 and 5 contacts (XLR series).
- Silver plated brass contacts rated between 7.5 and 20 amperes.
- Working voltages from 200 to 600 V a.c.
- Insulators of moulded melamine and neoprene.
- Low noise level when subjected to shock (XLR series only)
- Unique latch lever coupling mechanism for easy and rapid engagement/disengagement.
- Positive polarisation.
- Grounding/earthing provision through one longer socket contact (XLR series only).
- 15 shell styes.

**Write for XLR or EP Catalogue.**

# 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:*

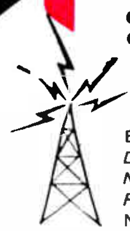
**connector research development, design and engineering; a fully equipped test laboratory; machine and model shops; toolroom; injection and compression moulding machines; quality control and inspection, etc.**

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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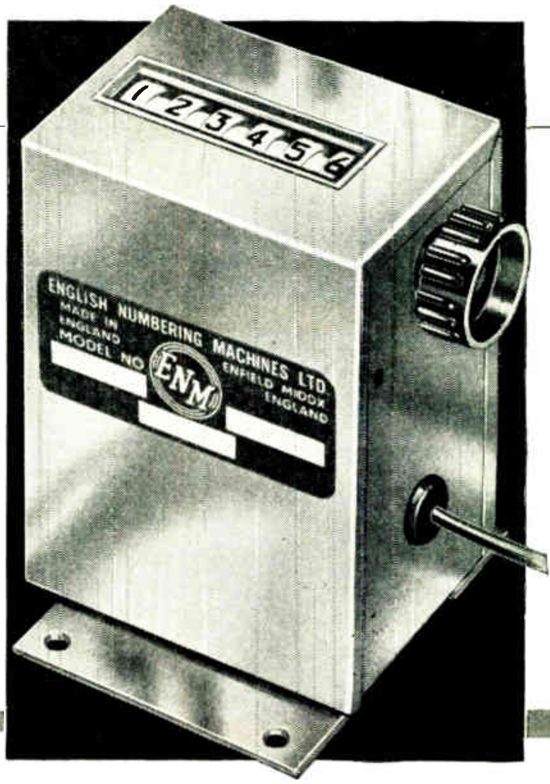
For further information circle 209 on Service Card

# Electro-Magnetic COUNTERS



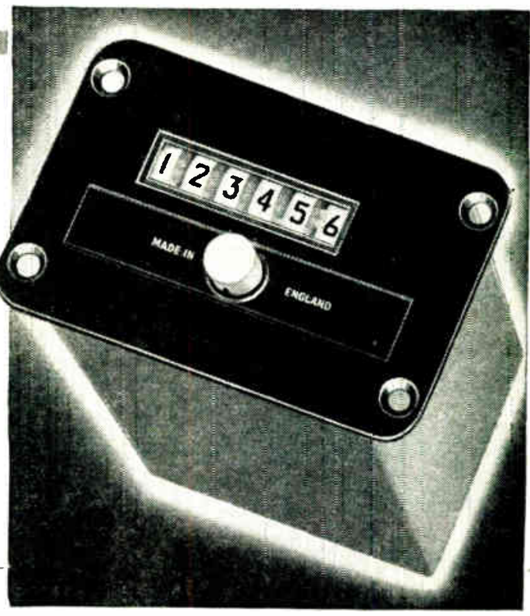

## MODEL 442

6 figures — adds or subtracts
Resettable by hand — or non-resettable
Standard Model — up to 500 counts per min
High Speed Model — up to 1000 counts per min
Standard Voltages

| | | | | | |
|---|---|---|---|---|---|
| DC | 12v | 24v | 48v | 110v | |
| AC | 115v | 230v | 50c/s | 115v | 60c/s |

Base or Panel Mounted
Panel size — 1·781 in (45·3 mm) × 1·250 in (31·8 mm)

**VISUAL OR PRINTING**
**ADDING AND SUBTRACTING**




## MODEL 443

Adds or subtracts — or adds and subtracts
Manual or Electric Reset, or non-reset
Standard Models — up to 2100 counts per min
High Speed Models up to 3000 counts per min
Standard Voltages

| | | | | | |
|---|---|---|---|---|---|
| DC | 12v | 24v | 48v | 60v | 110v |
| AC | 115v | 250v | 50c/s | 115v | 60c/s |

Panel mounted only
Panel size — 1·812 in (46.0 mm) × 2·75 in (69·0 mm)

*Write or telephone* **HOWard 2611** *for fully descriptive literature*

# English Numbering Machines Ltd

**DEPT E7 QUEENSWAY ENFIELD MIDDLESEX**
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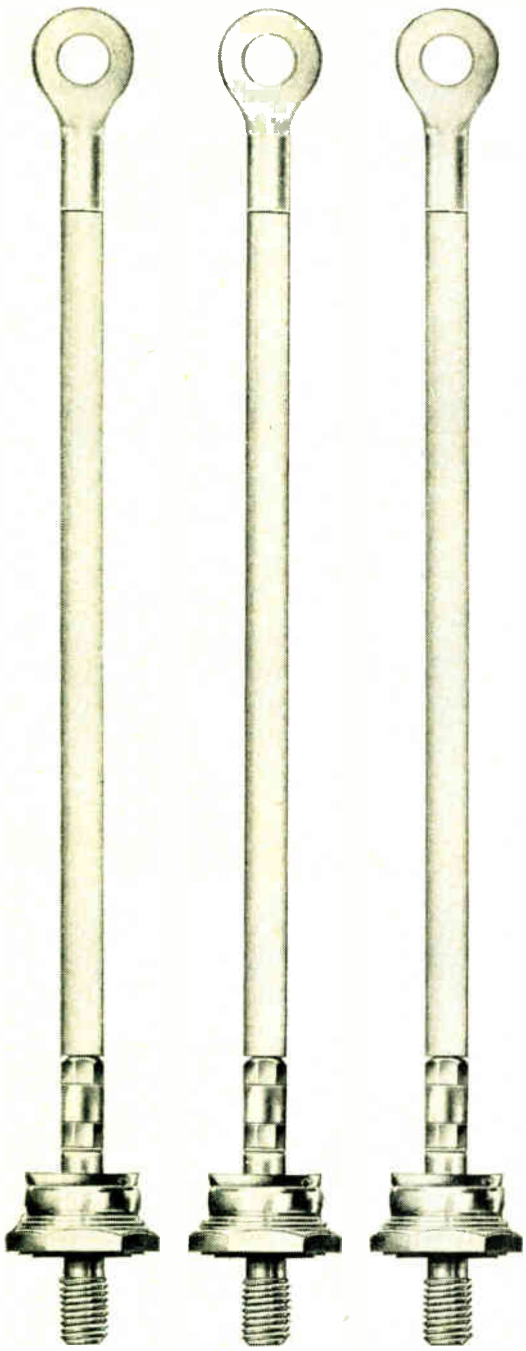
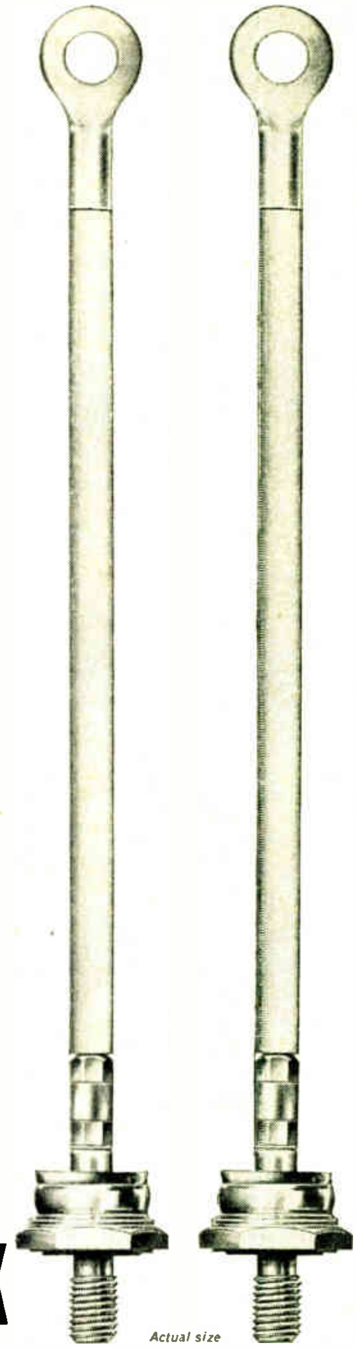
For further information circle 210 on Service Card



# STC

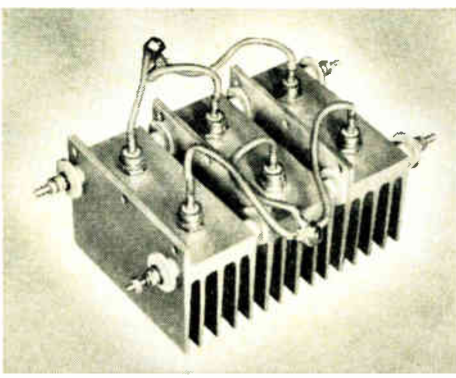
## 25 AMPERES SILICON RECTIFIERS with dual polarity

## AVAILABLE FROM STOCK



*Actual size*

25 amperes at 125°C stud temperature. 100 to 600 volts crest working voltage. These Type RS600 rectifiers are available with a choice of stud polarities to facilitate the assembly of diodes with heat sinks.
RS600 diodes conform to VASCA outline SO.32A and are flexible lead versions of VASCA outline SO.13, JEDEC DO-5 and IEC 1-104.



*Diodes and heat sinks assembled into stacks are available in all circuit configurations.*

**MAXIMUM RATINGS**
*(125 C STUD TEMPERATURE)*

| | |
|---|---|
| Average Forward Current | 25 A |
| Surge Current (5 Milliseconds) | 500 A |
| Crest Working Reverse Voltage | Up to 600 V |
| Non-Repetitive Peak Reverse Voltage (One Cycle) | Up to 800 V |
| Storage Temperature Range | −40 C to +150 C |
| Mean dissipation | 30 W |

**ELECTRICAL CHARACTERISTICS** *(MAX. VALUES)*

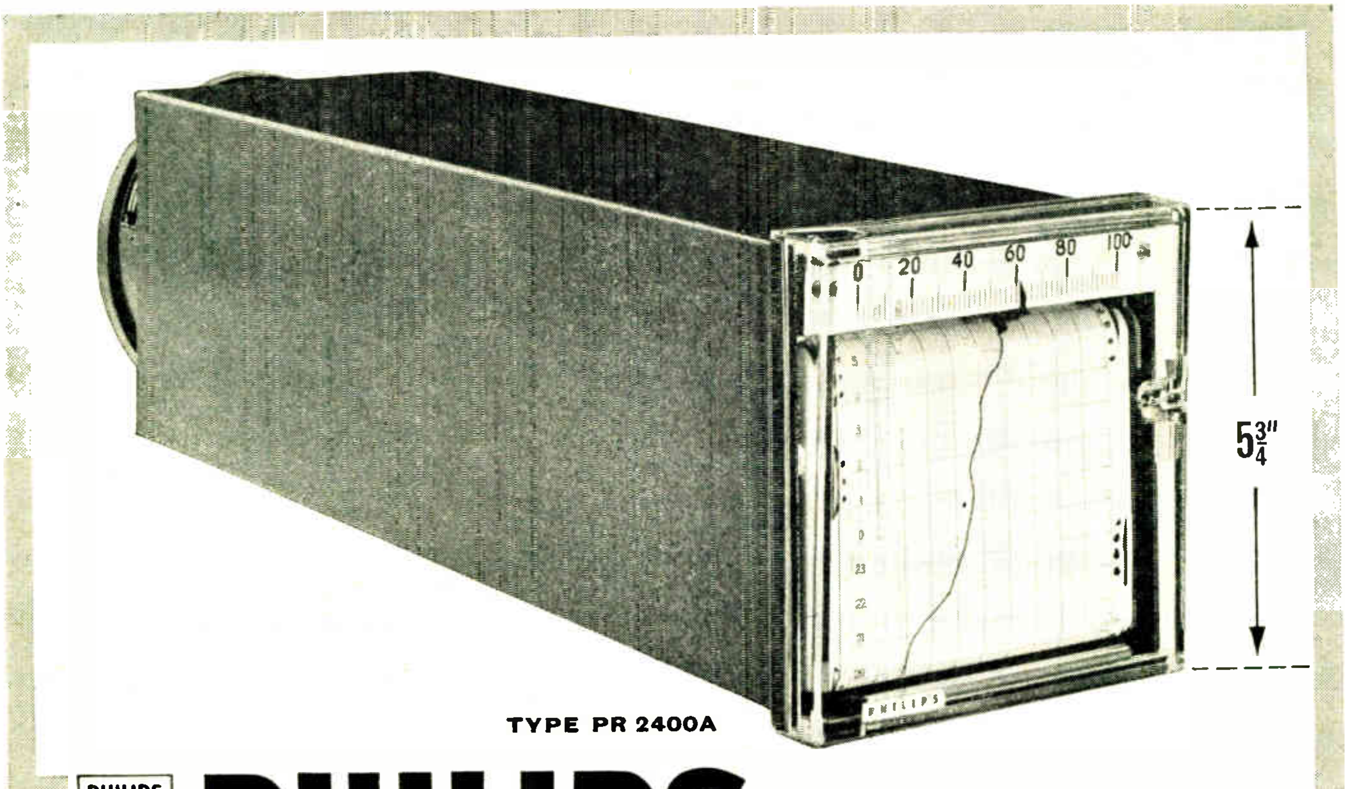
| | |
|---|---|
| Average Reverse Current at 125 C Stud Temperature and at Rated Voltage and Current | 1·5 mA |
| Forward Voltage Drop at 25 A d.c. | 1·1 V |

62/18MF

*Write, 'phone or Telex for Data Sheets*

RECTIFIER DIVISION
*Standard Telephones and Cables Limited*
EDINBURGH WAY · HARLOW · ESSEX · HARLOW 26811 · TELEX 81146

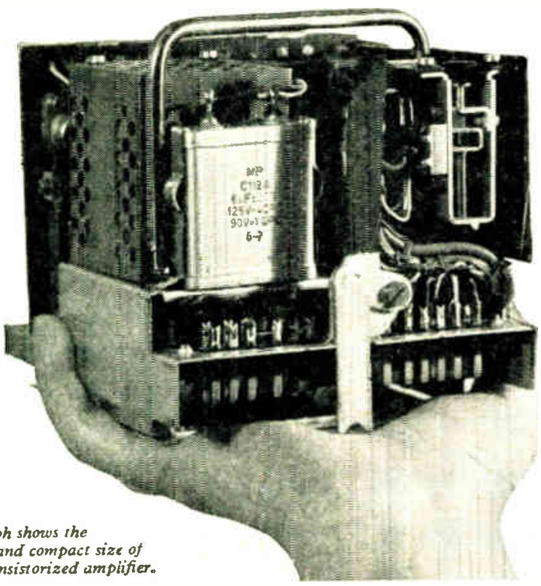
For further information circle 211 on Service Card




TYPE PR 2400A

PHILIPS

# PHILIPS MINIATURE RECORDER




*This photograph shows the lighter weight and compact size of the plug-in transistorized amplifier.*

**FEATURES** Small panel space of 144 x 144 mm (approx. 5¾" x 5¾") · Reliable null-balancing potentiometer system · Easily interchangeable ranges · Transistorized plug-in amplifier with printed wiring · Unique chart-winding system · High indicating speed and critical damping · Scale calibration for mV or all conventional thermocouples · Completely mains operated.

**RECORDING SECTION** Strip chart, width 100 mm, length approx. 9 m. The chart is wound into an exchangeable casette. Visible length of 100 mm. After opening the door the chart can be pulled out over a length of 80 cm. Chart returns automatically into the casette.

**CHART-SPEED** With built-in gear box 3 different speeds can be selected: 10, 20 and 60 mm/h. Can be supplied with electro-mechanical clutch so that by means of external switch chart movement can be accelerated by a factor of 60.

**RECORDING** With flexible capillary stylus supplied from sealed ink container mounted under measuring carriage. Line thickness approx. 0·3 mm.

**CONSTRUCTION** Sheet-metal case in grey hammertone with all-plastic door. Front dimensions 144 x 144 mm; depth 510 mm; panel opening 138 x 138 mm (5¾" x 5¾" – 20" – 5½" x 5½").

**Miniature mV-Recorder Type PR 2400A**

MINIMUM SPAN 5 mV · MAXIMUM SPAN 250 mV
ACCURACY 0·5%; the accuracy can be maintained after exchange of range box · REPRODUCIBILITY 0·2% of span
SCALE LENGTH 100 mm · STABILITY 10% mains variations have an influence of less than 0·1%
BALANCING SPEED Less than 1 sec. for full scale deflection; damping critically adjustable.

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(RCL0148)

# For your D.C. Control Systems

## D.C. POWER AMPLIFIERS type PA-1, PA-2, PA-3

Available in 20 watt or 100 watt output power ratings, these amplifiers require an input of only a few micro-watts. When used in closed-loop systems together with Reference Unit RU-1, they permit regulation of the controlled quantity to within ±0·5%.

*TYPICAL APPLICATIONS*

* *Driver Amplifiers for Saturable Reactors*
* *Alternator and Generator output Stabilisation*
* *Remote Position Control Systems*
* *Contactor or Solenoid Operation from very low power levels*

## REFERENCE UNIT type RU-1

A 30 volt 100 mA stabilised direct voltage source, for use as a reference in closed-loop systems. Incorporates electronic short circuit protection.

**H.E.D**

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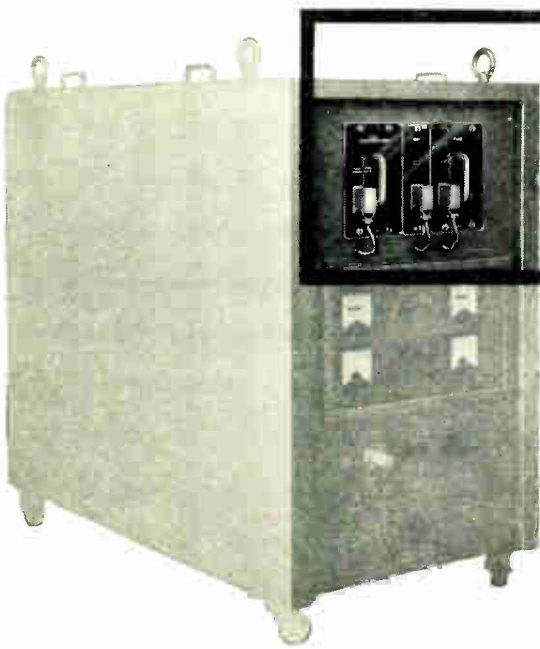
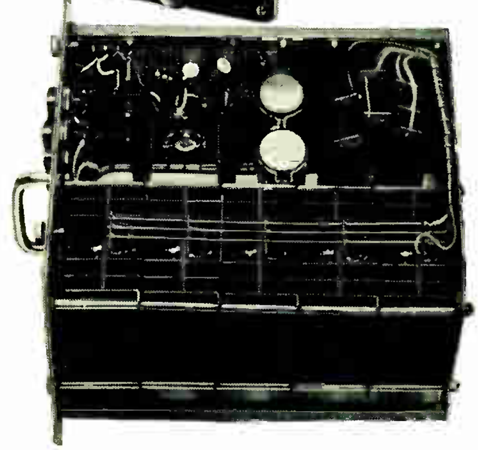
**UNITS**

Reliable and at moderate cost, these units are constructed in 'module' form for ease in servicing. All external connections are brought out to 18-way plugs on the front panels.



★ *Full technical details of all units supplied on request.*

PRICES (nett in UK)

| | | | | |
|---|---|---|---|---|
| PA-1 | Output | 20 watts | ... | £17 . 13 . 3d |
| PA-2 | ,, | 100 ,, | ... | £51 . 0 . 0d |
| PA-3 | ,, | 100 ,, | ... | £52 . 5 . 6d |
| RU-1 | ,, | 100 ,, | ... | £14 . 4 . 3d |

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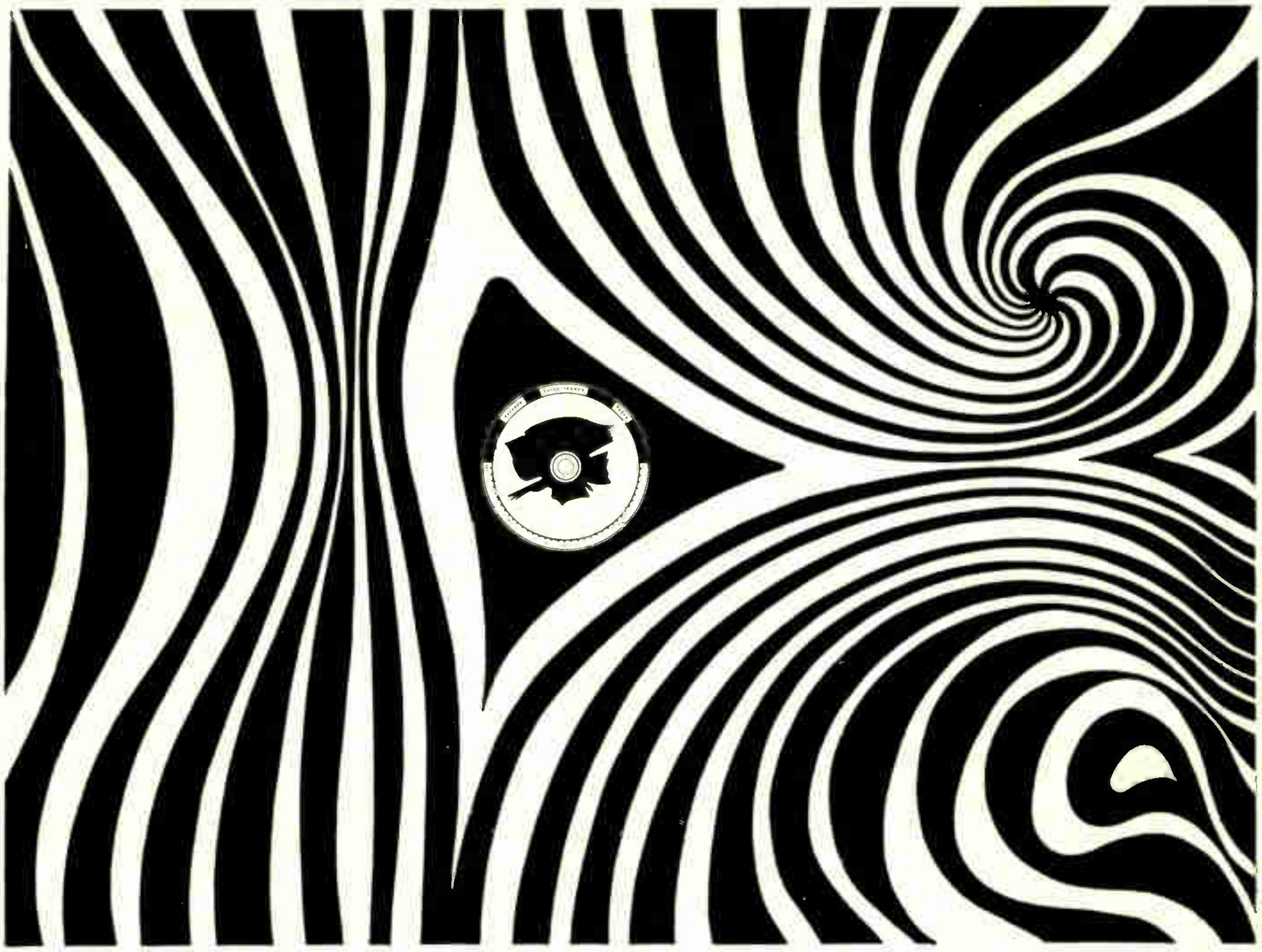
GATWICK ROAD, CRAWLEY, SUSSEX *Telephone — Crawley: 25721-2-3-4*



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New techniques can be applied to old problems, for the generator can be used in any application necessitating a repetitive cycle of events. Heartbeats, fuel-flow simulation, tidal effects, servo-system tests, load-cycles—


### VLF FUNCTION GENERATOR TYPE SG88

- 1. Frequency Range: 0.005—50 c/s.
- 2. Output Voltage Range: 200µV to 22V peak to peak.
- 3. Frequency Calibration Accuracy: ± 1% Full Scale.
- 4. Generation by servo controlled optical mechanical system.
- 5. Automatic frequency sweep facility.
- 6. Direction of rotation and waveform reversible.
- 7. Rapid change of waveform by interchanging glass discs.

NETT PRICE IN U.K. £475. 0. 0.

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ARCH systems to meet each requirement can be installed step-by-step from the range of basic modules. There is no waste of "computer power". These systems can be modified or extended as the need arises, by simply interchanging or adding modules with a minimum of cost and down-time.

ARCH is the *only* approach permitting an evolutionary development of complex control systems.

ARCH permits a number of levels of control. Executive planning at the head supplies directives to sub-management units at intermediate levels, which in turn supply more detailed instructions to individual process control units. Information on the performance of these process units is fed back to the sub-management level, which revises the instructions in order to maintain the objective. Manual intervention is possible at any level, and a fail-safe procedure is provided.

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**Reliability**
**High conductance**
**Low leakage**
**Fast recovery characteristics**
**Rugged, sub-miniature, all-glass construction**
**Operation up to 200°C**
**Low cost**

# general purpose diodes

## HS10

High forward conductance
Extremely low reverse leakage over wide temperature range
Max. average power dissipation 200mW
Nominal capacitance at -10V 5pF
Operating and storage temperature range -65°C to 200°C

**TYPE APPROVED CV7040***

'MICROSEAL'

| Type | P.I.V. | Max. Average Rectified Current (mA) | Max. Reverse Current at P.I.V. (μA) | |
|---|---|---|---|---|
| | | | 25°C | 100°C |
| HS1020 | 200 | 165 | 0.020 | 2.0 |
| HS1001 | 150 | 120 | 0.050 | 5.0 |
| HS1004 | 50 | 120 | 0.050 | 5.0 |
| *HS1007 | 150 | 90 | 0.050 | 5.0 |
| HS1010 | 50 | 90 | 0.050 | 5.0 |

HS1093 — Transistor base protection diode: $V_f$ at 100mA (25°C) ..............1.5Vmax; $I_b$ at 1.0V (45°C) ....................5μAmax; P.I.V. ............................5V; Max. D.C. current ..................100mA

ALSO MD456-8 and MD461 in micro-miniature package

# fast recovery computer diodes

## HS11

Stored charge at 10mA 700pC
Capacitance at -10V 3pF
Recovery time (JAN256 circuit) from 5mA to 80KΩ at -35V 0.3 μsec.
Max. average power dissipation 200mW

'MICROSEAL'

| Type | P.I.V. | Max. D.C. forward current (mA) | Typical Reverse Current at P.I.V. (μA) | |
|---|---|---|---|---|
| | | | 25°C | 100°C |
| HS1101 | 150 | 80 | 0.1 | 5.0 |
| HS1104 | 150 | 60 | 0.1 | 5.0 |
| HS1107 | 150 | 40 | 0.1 | 5.0 |

ALSO MD625, MD627-8 and MD662 in micro-miniature package

# ULTRA fast recovery computer diodes

## HD5000

Typical recovery time (to 1mA) 0.5 nanosec
Max. capacitance at 0V 1pF
Max. power dissipation 75mW

| Type | Min. Breakdown Voltage at -100μA | Max. Average Rectified Current (mA) | Max. Reverse Current at -5V (μA) | |
|---|---|---|---|---|
| | | | 25°C | 100°C |
| HD5000 | 20 | 12 | 0.2 | 2.0 |
| HD5001 | 20 | 12 | 1.0 | 10.0 |
| HD5004 | 15 | 12 | 1.0 | 20.0 |

actual size 

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*—or ask for a Sales Engineer to call.*

For further information circle 221 on Service Card

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## FOR EASY CIRCUIT MODIFICATION

AMPin-cert M Series Connectors give you complete freedom to modify circuits at will. Both pins and sockets, though secured in their housings by retention springs capable of withstanding a pull of 15 lb, can be instantly removed by the A-MP extraction tool. Thus contacts can be removed, replaced or interchanged at will. Furthermore, a defect in a single wire does not render the complete connector block inoperative as with conventional methods of attachment; the faulty wire can be removed and another substituted in an instant. A single A-MP extraction tool is suitable for use on pins and sockets of all ratings. *Write for new MDM Catalogue.*

**AMPin-cert Pins and Sockets**

• Controlled contact pressure • Fully floating contacts for exact alignment • No post insulation required • Contacts easily extractable and interchangeable • Low millivolt drop • Mouldings of 20, 26, 34, 50 and 104 cavity forms • Accessories include shields, cable clamps, guide pins and sockets and or jack screws • Complete crimping equipment for all production levels

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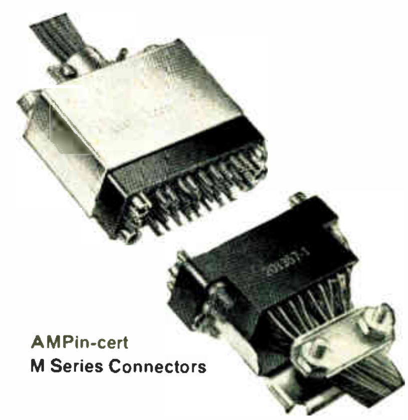

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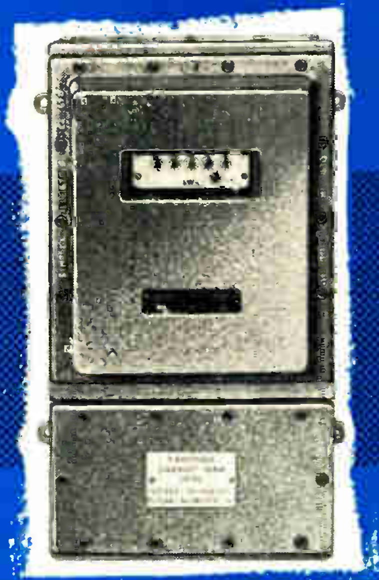

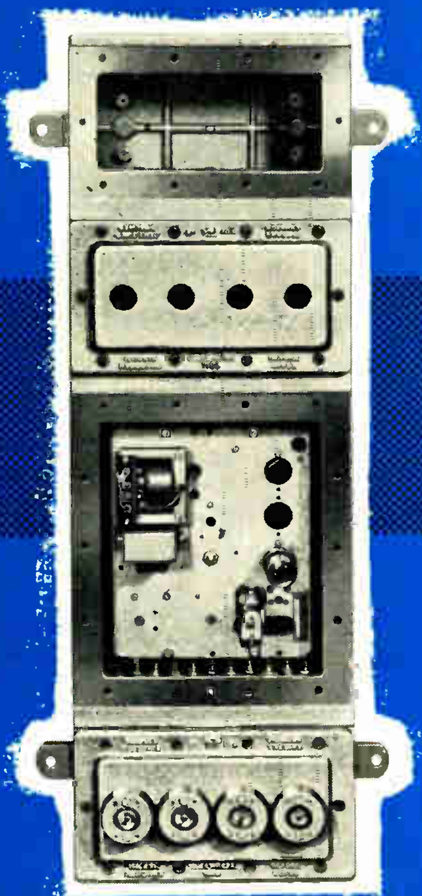

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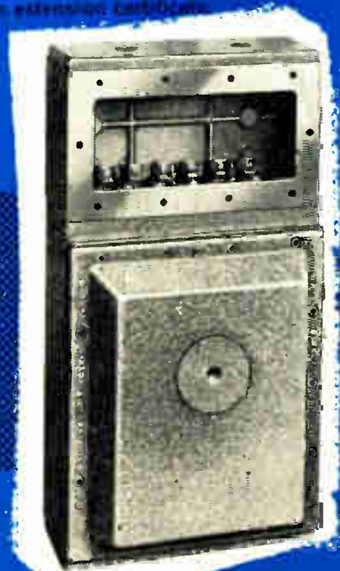

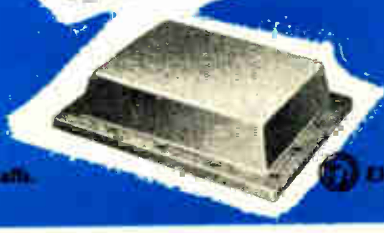

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Electrical Division

**Messages from the Chairmen of the Electronics Board of the British Electrical and Allied Manufacturers' Association and the Electronic Engineering Association**

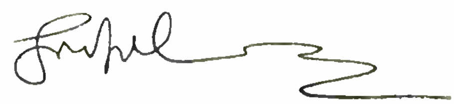
*The importance of electronic engineering in all its aspects and the tremendous changes it is bringing about in our lives is only now beginning to be appreciated. As Chairman of the Electronics Board of the British Electrical and Allied Manufacturers' Association, I welcome the advent of* Industrial Electronics *and congratulate the Publishers and Editor on the appearance of this first number. I am sure* Industrial Electronics *will play an important part in disseminating information about the technical progress being made in electronics, thereby accelerating the adoption of modern techniques throughout industry.*

(Sir Leon Bagrit)

Deputy Chairman and Managing Director, Elliott-Automation Limited

*It is certain that all sections of British industry must turn increasingly to electronics in the next decade as the most fruitful answer to the problems of increased efficiency and labour shortages.*

*The new journal* Industrial Electronics, *in setting out as it does to improve communications between the designer and manufacturer of electronic equipment on the one hand and the ultimate users in industry on the other, must be welcomed by all as a valuable new contribution in a vital field.*



(J. R. Brinkley)

Chairman, Electronic Engineering Association and Managing Director, Pye Telecommunications Ltd.

**COMMENT** *(Continued)*

thesis formulated to account for the practical experience that radio was not confined to visual ranges. The early development of radio was, in fact, retarded by scientists who stated categorically that longer ranges were impossible. Of course, if there were no ionosphere they would have been right.

Although we now make great use of the ionosphere, it is, like many natural phenomena, very variable. A great deal has been learnt about it, but a great deal more is still to be found out. A major aim is to improve the forecasting of its variations, so that radio communication links can be better planned and more efficient and reliable operation obtained.

To this end, the Radio Research Station of the Department of Scientific and Industrial Research is preparing to make soundings of the ionosphere from above. This is to be done with satellites developed in Canadian and American laboratories. Further soundings from below are being done with rocket-borne apparatus.

Who a few years ago would have foreseen that research into rockets might have in the future an effect on the reliability of overseas telephone calls?

# Television in Industry

*By W. TUSTING*

**In this article some of the industrial applications of television are reviewed. The apparatus usually operates on closed circuit; that is, a cable connection is employed between the camera and the picture reproducer.**

WHEN television is mentioned most people at once think of television broadcasting, of television as a medium of home entertainment. This is unquestionably its biggest use, but it is finding increasing employment in industry for purposes which can be conveniently classed as remote inspection.

A radio link between transmitter and receiver is not usually required. Cable connections are usual and an installation is then often spoken of as closed-circuit television. In such cases it is not necessary to adhere to the television standards used in broadcasting and the most suitable number of scanning lines for the particular purpose can be chosen. However, unless there are very good reasons for some departure from the normal standards of 405 or 625 lines, these are invariably employed.

The industrial applications of closed-circuit television are very varied. One is in the automobile industry; a television camera is mounted so that it views the front suspension and the viewing screen is inside the car so that an engineer can watch the behaviour of the suspension as the car is being driven over all kinds of road surfaces.

In banking television is used for the remote inspection of documents. One simple system has been installed by the Westminster Bank between a headquarters building in Manchester and two branches. A Pye 625-line system is used. At King's Cross railway station similar equipment is installed in the main signal box and used for passing information on the state of train arrivals to four different places in the station. Paddington is another station similarly equipped.

Railway marshalling yards, harbour control, traffic control and radiography are a few only of the places where closed-circuit television is in regular use.

The most obvious application, however, is in the viewing

*The title picture shows an E.M.I. Type 8 camera being used to give a picture at ground level of progress on the topmost floor of the new London College of Printing building at the Elephant and Castle, London*

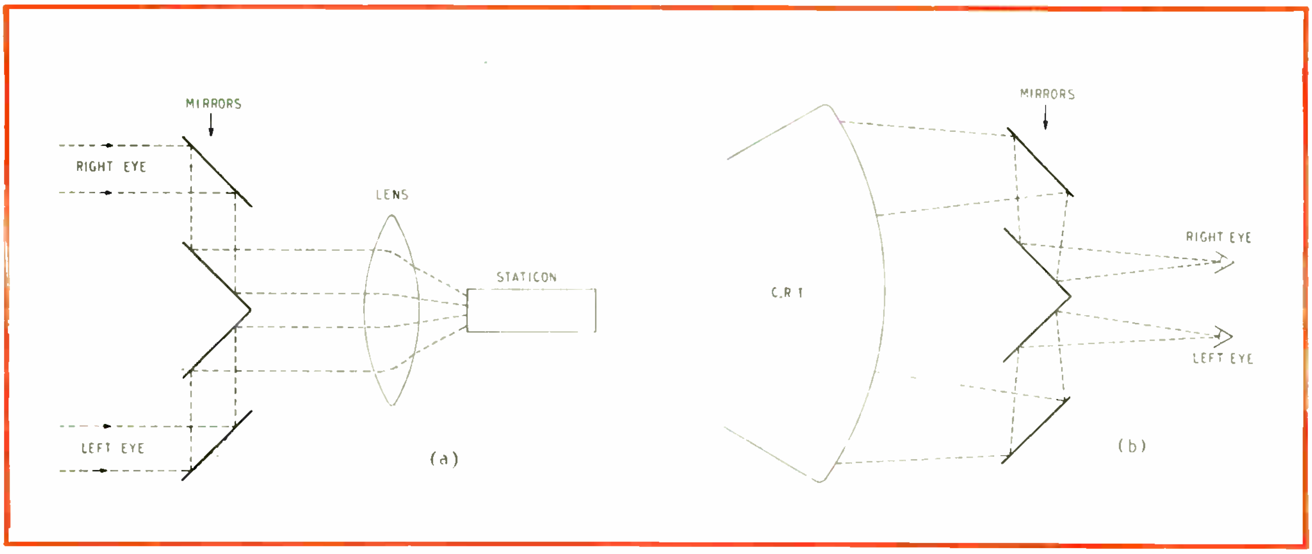



*Fig. 1.—The principle of the Pye three-dimensional television system is shown here. The mirror arrangement used at the camera is depicted at (a) and that at the receiving end at (b)*

*Pye television camera fitted with mirror system for three-dimensional pictures*

of processes which it would be dangerous to watch directly, either because of radiation hazards or because there is a risk of explosion or fracture. In other cases it may be desirable for one man at a central point to be able to watch one after another processes at various remote points in a factory. A television camera is then installed at each remote point, but at the central viewing point there are two possibilities. An independent receiver can be set up for each camera so that the viewer can sit facing all the screens and can glance from one to another at will. Alternatively, a single receiver may be provided and arranged so that it can be switched at will to present the picture from any camera.

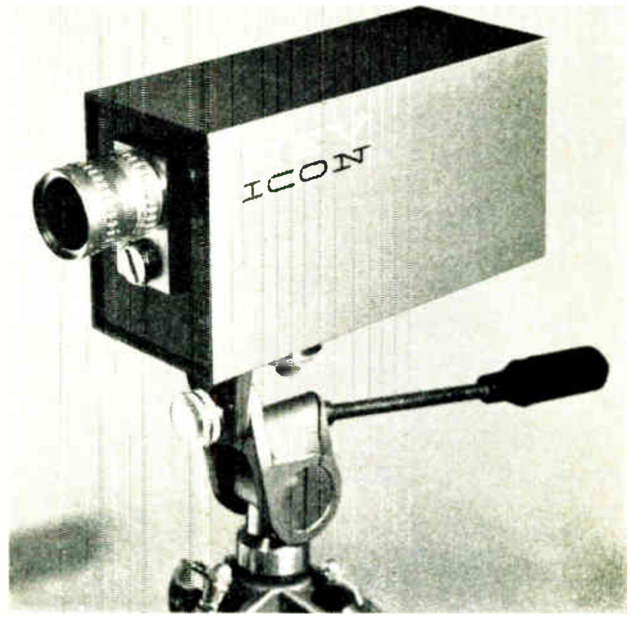
One use of closed-circuit television which usually surprises


*Ekco C 416 television camera for a 625-line standard. Completely transistorized and needing only a 200-250 V a.c. supply, it provides an output suitable for direct connection to a domestic 625-line receiver. A remote control of sensitivity can be fitted* the uninitiated is in providing remote indication of meter readings. In large installations it is often desirable to have at a central point the readings of meters which are located at remote points. This is basically a telemetry problem to which there are all sorts of possible solutions. The obvious one of extending meter connecting leads to the central point is often ruled out on the grounds of reliability. The possibility of broken connections with a large number of such wires is considered too great. By grouping the meters at the remote point close together a single television camera can view a dozen or more simultaneously, a single cable connection only is needed and the viewing screen, of course, presents a picture of the whole group of meters which can be read just as if one were at the remote point. A major advantage, of course, is that there is no possibility of errors being introduced in the communication link. A fault in the television system cannot produce an error; all that it can do is to make it impossible to read the meters; and then the operator knows at once that something has gone wrong.

In some industrial processes stereoscopic television is desirable. This occurs when the remote manipulation of dangerous substances is necessary, and to control the manipulators it is necessary to be able to see what one is doing as with normal binocular vision. This is usually done with a single television camera and viewing tube, although it can be done by using two separate systems. The two cameras are then arranged at a slight angle to each other to view the scene from different positions. The resulting pictures from the two monitor tubes are superimposed by mirrors and polarized glass and the viewer wears polarized spectacles.

A single channel system developed by Pye Ltd. has a mirror beam-splitting arrangement at the camera and another mirror-viewing system at the picture reproducing end. The sketch of Fig. 1(a) shows the former. The two outer mirrors reflect right and left eye views of the subject on to the inner pair of mirrors which in turn reflect these views through the focusing lens to form right and left pictures side-by-side on the target of the Staticon camera tube.

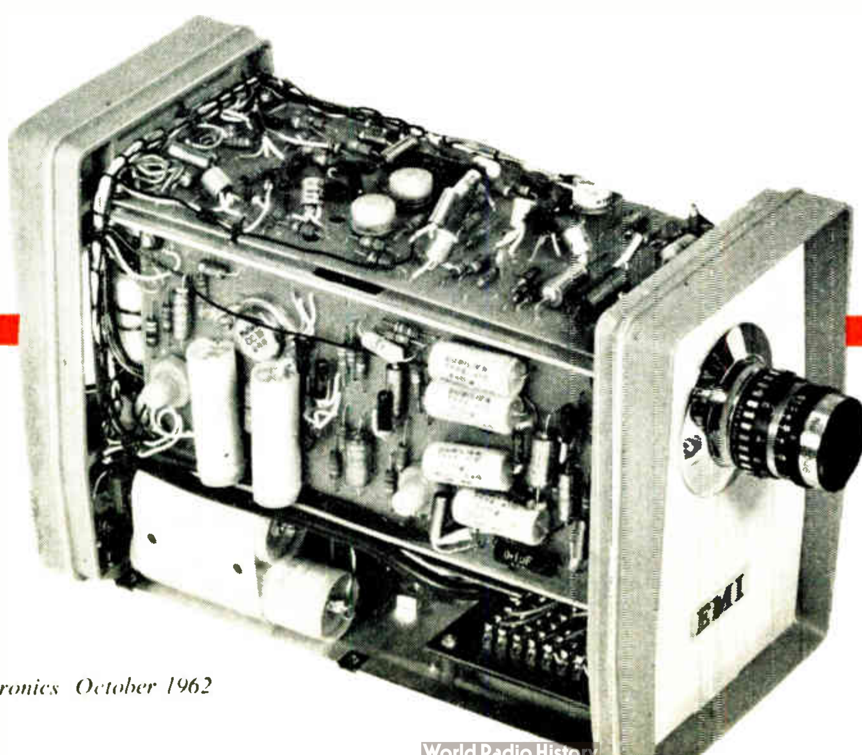
In the receiver, Fig. 1(b), right and left eye pictures are formed on the screen of the cathode-ray tube and a series of mirrors presents them to the eyes of the viewer. The viewing position is such that each eye can see only one of the pictures. This system introduces no electronic complication, for the stereoscopy is obtained by purely optical means.




*The New Icon has no external controls and weighs 4 lb. The standard model is for a.c. supplies and the output is 5 mV in any Band I channel. It can be supplied for 405, 525 or 625-line standards and is used with any domestic receiver*

Stereoscopy is not normally required in closed-circuit television, neither is colour. Yet colour systems exist and have application for special purposes. One of the most valuable of these is in the training of medical students, for a colour television system enables a much larger number to watch in much more detail operations as they are performed by the surgeon. A single camera can feed a large number of viewing tubes and each tube can be seen by a dozen or so students.

Colour systems are expensive and are likely to be used




*This picture shows the E.M.I. Type 8 camera with its cover removed. Good accessibility is obtained by easily removable panels* only where colour is absolutely essential. The normal industrial television system is single channel and gives a black-and-white picture. One of the latest is based on the new Type 8 camera produced by E.M.I. Electronics Ltd. This camera weighs only 10 lb and can be operated either from a 12-volt car battery or from a.c. mains. It gives either a video output for use with precision viewing monitors or an r.f. output in the normal television broadcasting bands, so that a standard domestic television receiver can be used for viewing.

When using the r.f. output up to 1,000 feet of cable can be used, but with the video output 100 feet is about the limit.

The camera measures only 11 × 7 × 5 inches and consumes 15 watts from an a.c. supply, or 1 ampere from a battery. It can be supplied to any of the normal television standards: British, 405 lines, 50 fields and positive modulation; European, 625 lines, 50 fields and either positive or negative modulation; and North American, 525 lines, 60 fields, negative modulation.

No mention has so far been made of the cost of closed circuit television. This naturally varies very much according to the facilities which are required. As an example, however, the E.M.I. Type 8 camera just mentioned costs £160 complete with the Vidicon camera tube and a 1-inch f/1·9 variable-focus lens. With cable and a domestic-type television receiver, the total cost of one such closed-circuit link should not exceed £250.

Where a camera is required to produce a picture of one fixed scene it can be set up to do so and a camera operator is unnecessary. He is not always needed, however, even when camera adjustments are required for, at extra cost, some cameras can be fitted with remote control facilities. It is only rarely under industrial conditions that a permanent camera operator is necessary.

Normal cameras are fitted with light-sensitive tubes and the sensitivity is adequate for normal lighting conditions. Special lighting of the scene is thus not always required. It is not always realized that special ultra-violet or infra-red sensitive tubes are obtainable. With these it is possible to obtain a normal picture when the scene is, as far as the eye is concerned, in total darkness. With the ultra-violet sensitive tube it is necessary to arrange for the scene to be lit by ultra-violet 'light.' With the infra-red sensitive tube, however, special 'lighting' may not be needed for the temperature of most natural objects is sufficiently high for them to radiate in the infra-red region of the spectrum.

# AUTOMATIC ULTRASONIC DEGREASING

THE introduction in recent years of automatic polishing and automatic plating plant together with overhead type conveying systems has shown the possibility of a fully automated series of stages taking the workpiece in its original manufactured condition and subjecting it in turn to automatic polishing, automatic cleaning and automatic plating processes.

The automatic polishing and plating systems are now conventional equipment, but the fast and effective removal of polishing compound residues, from such things as aluminium die-castings, brass pressings, cutlery, etc., prior to plating has always presented a difficult manual problem.

The most effective method devised to date calls for the immersion of workpieces in a hot, ultrasonically-activated, chlorinated solvent followed by suspension in a chlorinated solvent vapour zone.

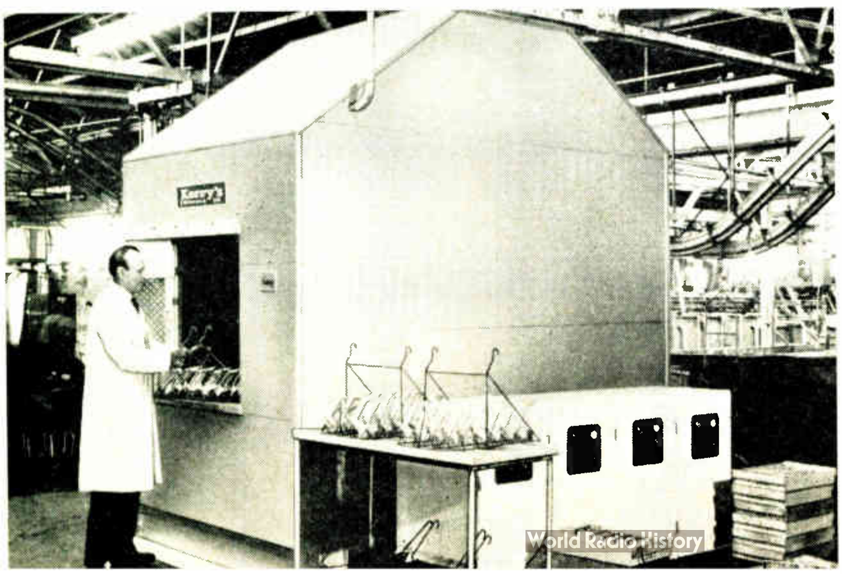
The solvent in the immersion section is normally maintained at a temperature of between 70 and 80 °F. Ultrasonic transducers operating at a frequency of 40 kc/s in the base of the tank provide complete activation of the cleaning solvent. The ultrasonic energy forces the hot solvent into intimate contact with the surfaces of the workpieces; solution of the polish base and dispersion of the compound particles takes place simultaneously. An average immersion time of one minute is allowed. After cleaning, workpieces are suspended in the vapour section, which operating on normal degreasing principles provides a final rinse off and heats up the workpieces to allow a stain free 'flash off' on removal. The dwell period in the vapour zone normally coincides with the primary cleaning period.

Hand operating cabinet type plants of this nature have been manufactured for several years now by Kerry's (Ultrasonics) Ltd. who have recently developed a fully automatic rotary wheel type plant in conjunction with Messrs. Norman Hay Ltd. who have installed the equipment in the automatic polishing and plating line at their Harmondsworth, Middlesex, Works.

The plant delivers one work load (average size 24 in. × 18 in.) clean and dried ready for subsequent plating every 45 seconds. The complete equipment is self-contained and measures 9 ft 3½ in. long by 8 ft wide by 13 ft 5½ in. high (3 ft 3 in. of which is sunk below floor level).

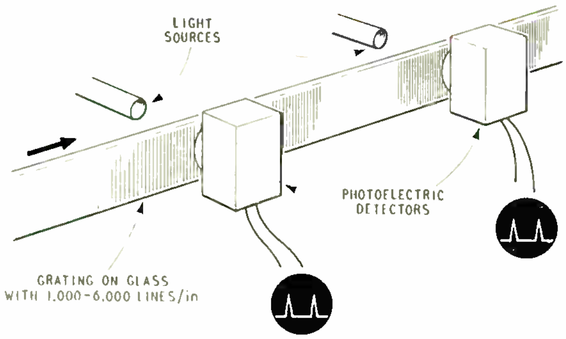
A fume extraction system is fitted and all mechanical and liquid stages are controlled by thermostats and safety switches. The equipment has been designed as Type RW.4 and is now available as a standard production unit.

**For further information circle 35 on Service Card**




*This picture shows the Kerry fully automatic rotary wheel type ultrasonic degreaser installed in a plating works*

# Calibrating Scale Gratings Electronically

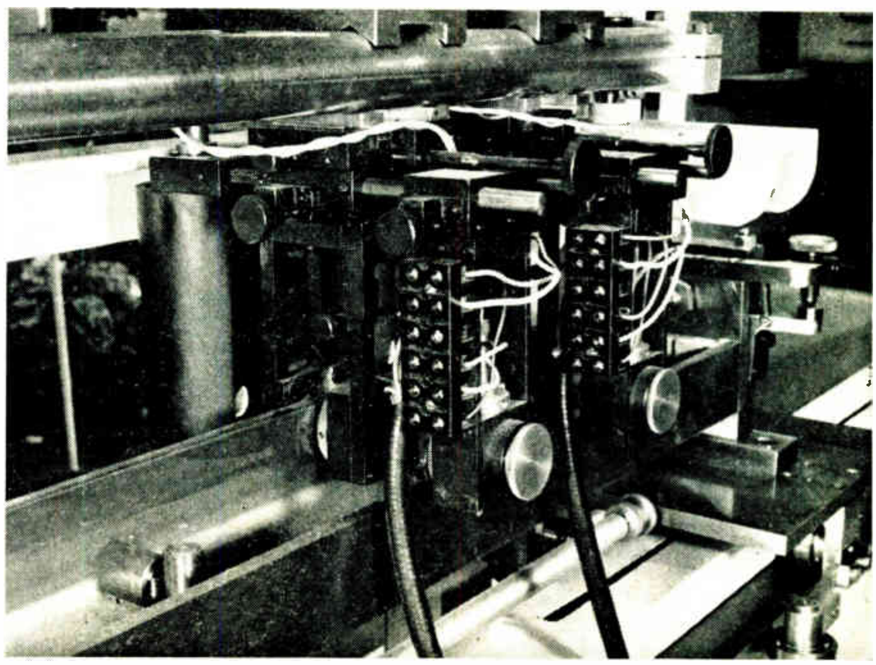


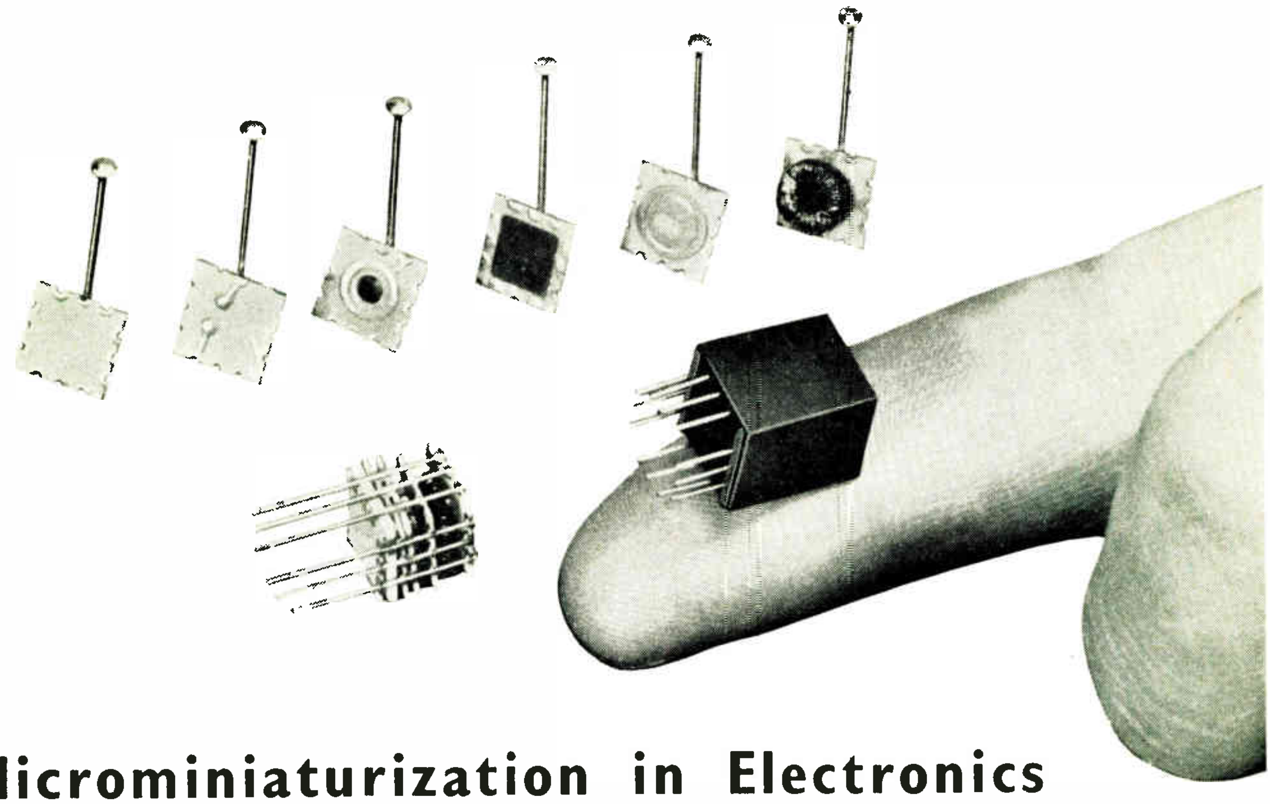

*This simple sketch shows the principle of the instrument and the position of the photoelectric detector head and their respective light sources*

During the Industrial Research and Productivity Exhibition, D.S.I.R. were showing a new automatic instrument which has been developed by the National Physical Laboratory for calibrating scale gratings. These gratings (closely and uniformly-spaced lines on glass plate or steel tape) are being used in conjunction with photoelectric detectors, by a growing number of machine-tool manufacturers for the automatic control of machines. Although scale gratings usually contain 1,000 lines or less to the inch, the number can be as high as 6,000 and verifying their accuracy is a laborious job. Since this new instrument makes use of many more observations than earlier methods and also requires less time, the new operation should be more accurate—not only because of the greater number of measurements, but because temperature changes will be less likely due to the shorter time taken for measurements.

The photograph shows the two reading heads, which are a known distance apart, and the drawing helps to identify the component parts. The grating moves at a known speed past the two heads and the output signals from the photoelectric heads are converted into pulses. The output pulses are compared with the output from an oscillator and the information is recorded on punched-paper tape and analysed by a computer.

*This illustrates the instrument and shows the rigid construction required to ensure stability and accuracy of measurement*





# Microminiaturization in Electronics

*By PAUL JEFFRIES*

**This is a brief survey of the three most popular techniques being developed at present to reduce the size and weight of electronic apparatus and at the same time increase its reliability and reduce the cost.**

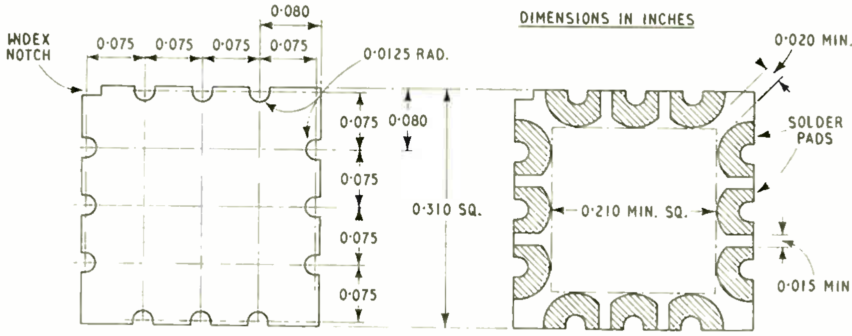
AN obvious and natural evolution in the field of electronics has been the miniaturization of equipment. Along with this, the user of electronic equipment is demanding more reliable and cheaper devices—which means that a new approach has had to be made to miniaturization.

For many years, miniaturization has meant making smaller and smaller components, of a conventional type, and trying to squeeze more and more into a given volume. This technique obviously has its limitations and even with modern sub-miniature components and transistors the ultimate practical component packing density is about 50,000 components per cubic foot. Also, if normal production methods are used, the reliability will not be any better than that obtained with standard-sized assemblies. Therefore any new development in miniaturization would have to have as its goal the reduction in size and the weight of a given equipment, while simultaneously making it more reliable and cheaper. Initially, back in the late 1950s, opinions on what was a realistic figure of improvement in size and reliability were varied, but an improvement of about 10 : 1 in size and weight and reliability was considered feasible. And so, many and varied ways of miniaturizing electronic equipment were developed and, naturally, many names were coined for these developments, including microsystems, microelectronics, micromodules, microcircuits, solid circuits, molecular circuits, etc., etc. The best known of these are the micromodule, microcircuit and solid circuit.

### Micromodules

The micromodule technique combines small elements of uniform shape and size into modules, and a number of modules are connected together to perform a required function. A development programme for micromodule electronic devices was originated in 1958 by the U.S. Army Signal Corps with the Radio Corporation of America acting as prime contractor and many American companies developing micromodules as sub-contractors. This means that the best known developments in this field are invariably referred to as R.C.A. micromodules. These micromodules comprise a number of ceramic wafer-like elements, measuring 0·31 in. × 0·31 in. × 0·01-in. thick, which are connected together, one on top of the other, to form a stack or complete module; the height of each module depends on the function. Fig. 1 shows the dimensions of the wafers and the arrangement of the solder pads. The elements may be active and contain

*Fig. 1. This sketch shows the dimensions of the ceramic wafers and the position of the solder connections for each wafer*



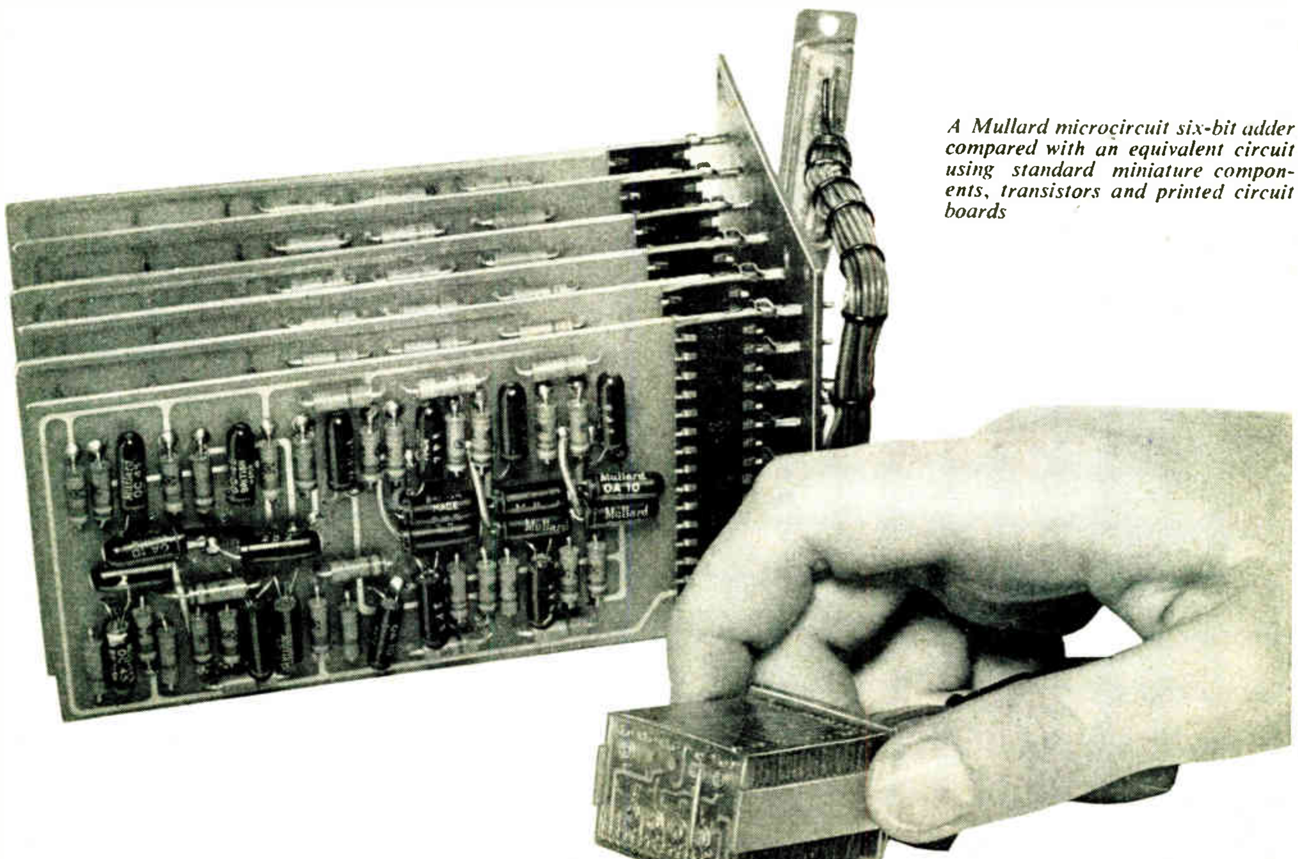

diodes and transistors, they may be passive and contain resistors, capacitors and inductors only or they may combine both active and passive components. The components are each designed with minimum height. This is achieved by depositing thin metal film resistors on to a substrate or insulating base, and depositing capacitors and some conductors on a substrate; transistors and diodes are made flat and mounted in the element wafers. The title illustration shows an exploded view of an R.C.A. micromodule and a complete module.

So far, no reference has been made to the way in which improved reliability and lower production costs are achieved. This is because these micromodules are still in the development and appraisal stage. However, it is planned to produce the individual elements in large quantities using automatic assembly techniques and automatic machines are to be used to assemble the elements into modules. These methods coupled with automatic testing will help to eliminate human errors and, it is hoped, will result in a significant improvement in reliability. During a study of the reliability of R.C.A. micromodules, operating life tests have demonstrated a mean-time-of-failure of 99,421 hours for a ten-part module.

## Microcircuits

This form of miniaturized electronic circuit seems to be more popular in England, from a development point of view, than any other. These microcircuits basically consist of a rectangular substrate or insulating base on which components such as resistors and capacitors have been deposited by evaporation; holes are made in the substrate to accept transistors and diodes.

With this technique it is possible to build up a complete circuit including passive and active components on to a



*A Mullard microcircuit six-bit adder compared with an equivalent circuit using standard miniature components, transistors and printed circuit boards* single base or substrate. Not only is it possible to evaporate conducting and resistive material in any given pattern on to the substrate, but dielectric materials can also be deposited. Fig. 2 illustrates simply the stages of production of four capacitors. First, a conducting strip is evaporated on to the base, this acts as one electrode and is common to all capacitors. Secondly, a dielectric film is deposited over the electrode, leaving a small area to which contact is made. Thirdly, four separate electrodes are deposited on top of the dielectric and finally contact is made to the four electrodes. If it was required to include a diode or a transistor on the same substrate, then a hole would be made in the substrate and a flattened transistor or diode would be dropped in and connected into circuit by wires. Current development shows that it is possible to build a transistor or diode into a recess in the substrate and thereby increase the packing density.

Mullard Ltd. have been developing various microcircuits for over two years and are now ready to manufacture devices for industrial applications. The illustration on page 9 shows an example of Mullard microcircuits, some of which have been produced for the Ministry of Aviation, and on page 10 is shown an operator loading microcircuit plates into a jig for the vacuum deposition of component electrodes. With these microcircuits it is aimed to provide a component packing density of about 500,000 components per cubic foot.

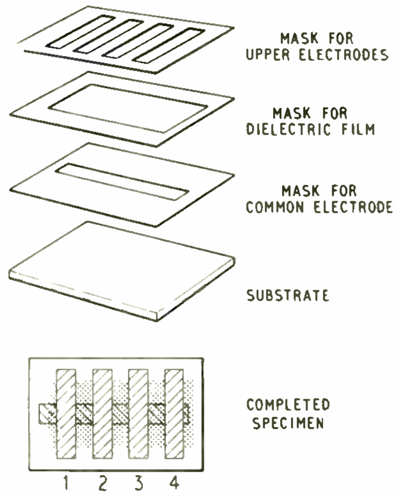
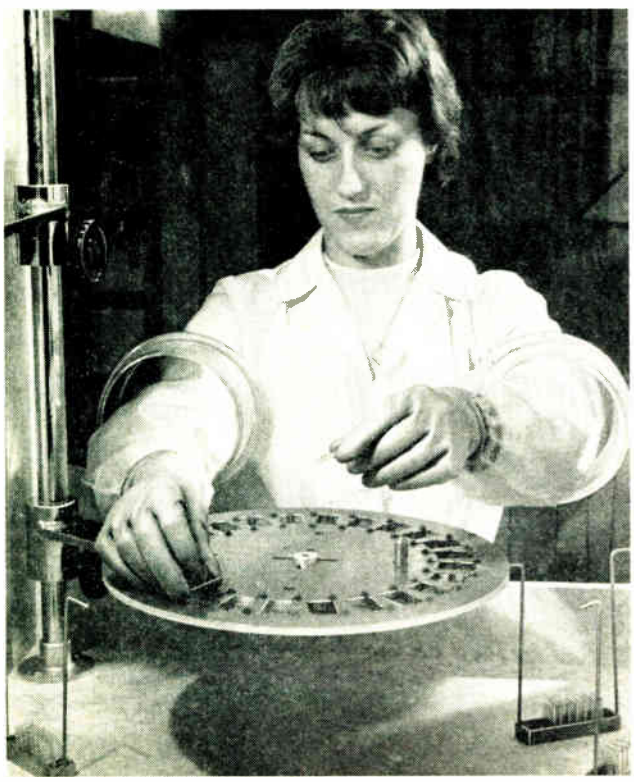



*Fig. 2. This shows the masks used for depositing four capacitors on to a substrate. It also serves to illustrate the technique employed in producing microcircuits*

### Solid Circuits

In this final approach to microminiature electronics both passive and active components are integrated into one block of semiconductor material. This is the most advanced form of microminiaturization yet devised and at present it is in the very early research and development stage. One or two companies are offering solid circuits for sale but these are very costly and are limited.

*Here the operator is loading microcircuit plates into a jig for vacuum deposition of component electrodes*



This technique is really an extension of that employed for the manufacture of transistors and semiconductor diodes. While both silicon and germanium have been used for solid circuits, silicon is considered superior on three counts: (1) because of its higher intrinsic resistance; (2) because it is easier to form diffusion masks on silicon than on germanium—this makes it easier to produce active and passive components in a silicon block; and (3) silicon will withstand a higher temperature than germanium—this is important when one considers that component packing densities exceeding 10 million components per cubic foot are envisaged with solid circuits.

Like transistors, solid circuits start off as blocks of single-crystal semiconductor. By heating the semiconductor in a controlled atmosphere it is possible to change the electrical characteristics of the outside layer of the material—the depth of penetration of the change of characteristic depends on the length of time the semiconductor is held at an elevated temperature in the controlled atmosphere. In the diffusion furnace the diffusant, which changes the surface characteristic of the silicon, is heated in a furnace until it evaporates at a controlled rate and it is carried to the heated semiconductor by gas flowing through a quartz furnace tube. By arranging for the slice of silicon to be masked, with a material that prevents the diffusant from diffusing into the silicon, it is possible to change the characteristics of discrete areas of the silicon slice. This means that in addition to being able to produce transistors and diodes on a slice of silicon, resistors can be 'diffused-into' the silicon slice to connect any two points, this is also true of conductors. Capacitors can also be produced in a similar way by forming p–n diodes, which will act as voltage-dependent capacitors.

It is, therefore, possible to produce a complete circuit from a single block of silicon by diffusion and removal of material by selective acid etching.

Two firms in England have announced that they are producing solid circuit devices. The first is Texas Instruments Ltd. The second is Ferranti Ltd. who are producing NOR computer switching circuits in shortened transistor cases. These circuits are actually made up from two separate solid circuits which are joined together with wires. One part of the circuit comprises 1 transistor and 4 diodes and the second part comprises 2 diodes and 1 resistor; both start off as slices of single-crystal silicon. Other Ferranti solid-circuit developments include a chopper type d.c. amplifier.

**A method of achieving automation gradually by introducing individual control units one at a time is described. It enables improvements in production to be obtained in properly graduated steps and is flexible enough to allow technical advances in techniques to be accommodated.**

# Step-by-step automation

THE concept of automation has been with us now for quite a few years but it is very rare indeed to find it fully applied in practice. The completely automatic factory is still as elusive as Eldorado. There is a good reason for this. It is not merely that the cost is very high indeed, but that it takes so long to analyse the requirements that there is a serious risk of technical advances catching up and making the automatic factory out of date before it is even in operation. This has been realized by the Elliott-Automation Group and in consequence they have devised a step-by-step approach to automation. A normal factory process consists of many automatic or semi-automatic machines which operate in turn upon the product. The machines are controlled or adjusted by people who endeavour at each stage to keep a machine running at optimum efficiency while accepting the full output of the previous machine and feeding the proper output to the next machine in the chain. Natural variations in the raw material affect the required processing and the operators take care of these, or attempt to, by adjustments to the machines, often by rule-of-thumb methods.

Each operator requires information some of which he gains from meters and other indicators on the machines. Other information comes from other operators higher or lower in the chain. Each operator is thus a link in the general information chain and also a processor of information, since he has to digest it and decide upon the proper course of action to take.

The assembly of information channels associated with the control of a process is called the *process information mesh*. It embodies all so-called mathematical models representing plant behaviour but it goes further to include effective recognition of the 'rules of thumb' used by the majority of process operators.

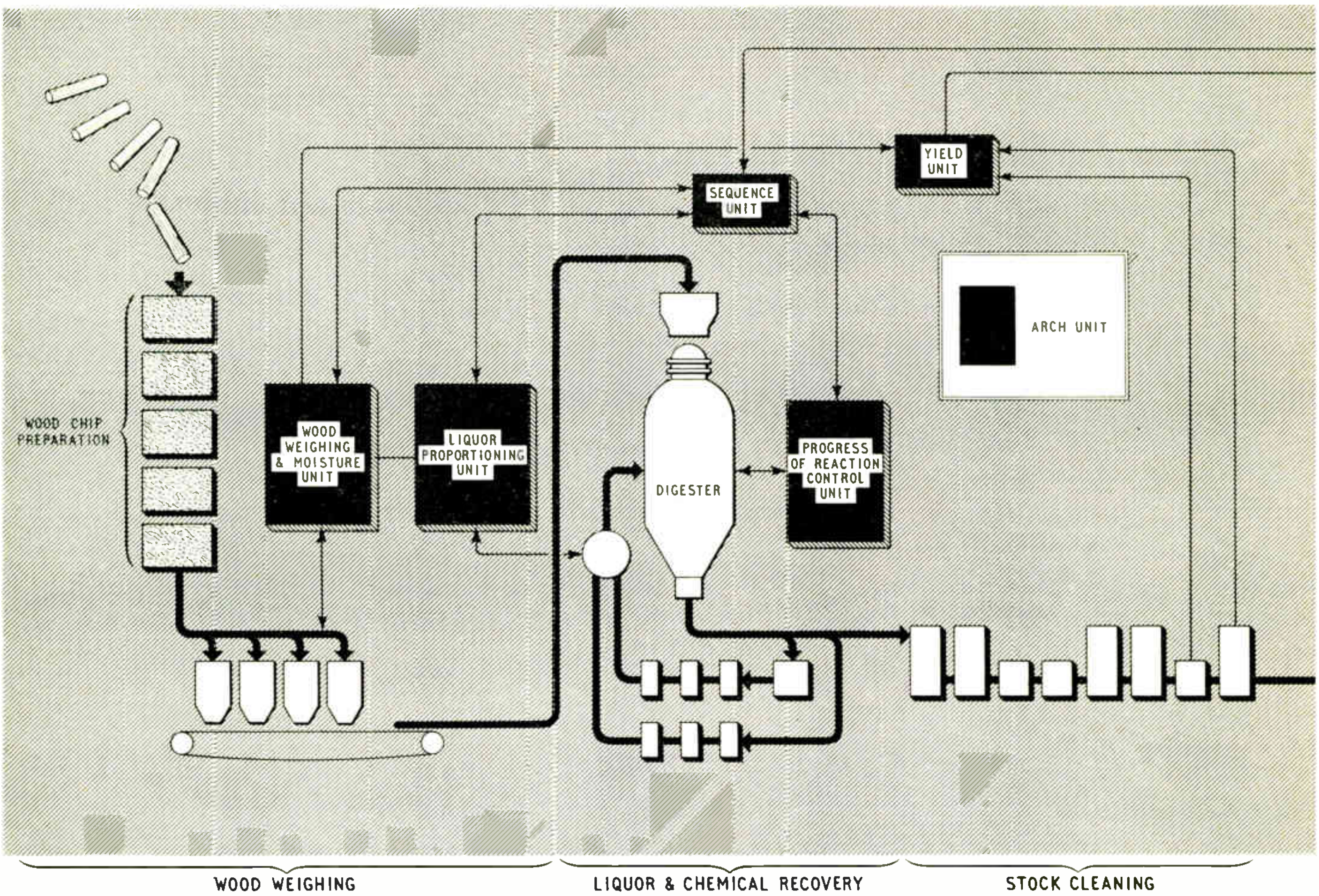
Recognition of the information mesh is fundamental to automation for it is by automatic operation of the information mesh that automation is achieved.

It is obvious that transference of the information channel to a machine medium can be effected only if it is possible to recognize the channel and define the information flow in it.

The information channels are rarely confined to the immediate vicinity of the unit process. Integration of even a few units in a works leads to surprising numbers of channels interweaving among the units and extending upwards to higher levels in the management structure and outwards to supply sources and to customers.

An apparently satisfactory solution is the provision of a comprehensive general purpose computing machine fed with all relevant data from plant transducers and from customer order information, etc., programmed with a complete set of rules and process characteristics and capable of generating all necessary instructions and control data for direct transmission to process plants.

The difficulties in this solution are immense. For all but the simplest plants the capital expenditure is heavy and with no predictable return on investment no customer could be blamed for deciding against it. The detailed knowledge of the work information mesh is certainly not available now and this expensive equipment would perform for a long time a data gathering role in support of operational research entirely without financial yield. Such a machine would almost certainly become a white elephant in any rapidly developing industry through the changed pattern of requirements existing before it could be brought fully into operation. In addition the effect on morale involved in delegating so much responsibility to one complex machine would be disastrous.




*This diagram illustrates the application of the Elliott-Automation Arch system to corrugated box production. The system for complete automation is shown but as explained in the text the various units can be introduced gradually. Initially, the wood weighing and moisture unit might be installed, followed later by the liquor proportioning unit. Then the progress of reaction control unit might be added, and so on*

In some cases the use of a number of general purpose computers can be used. But for small works it may not be an economically allowable answer.

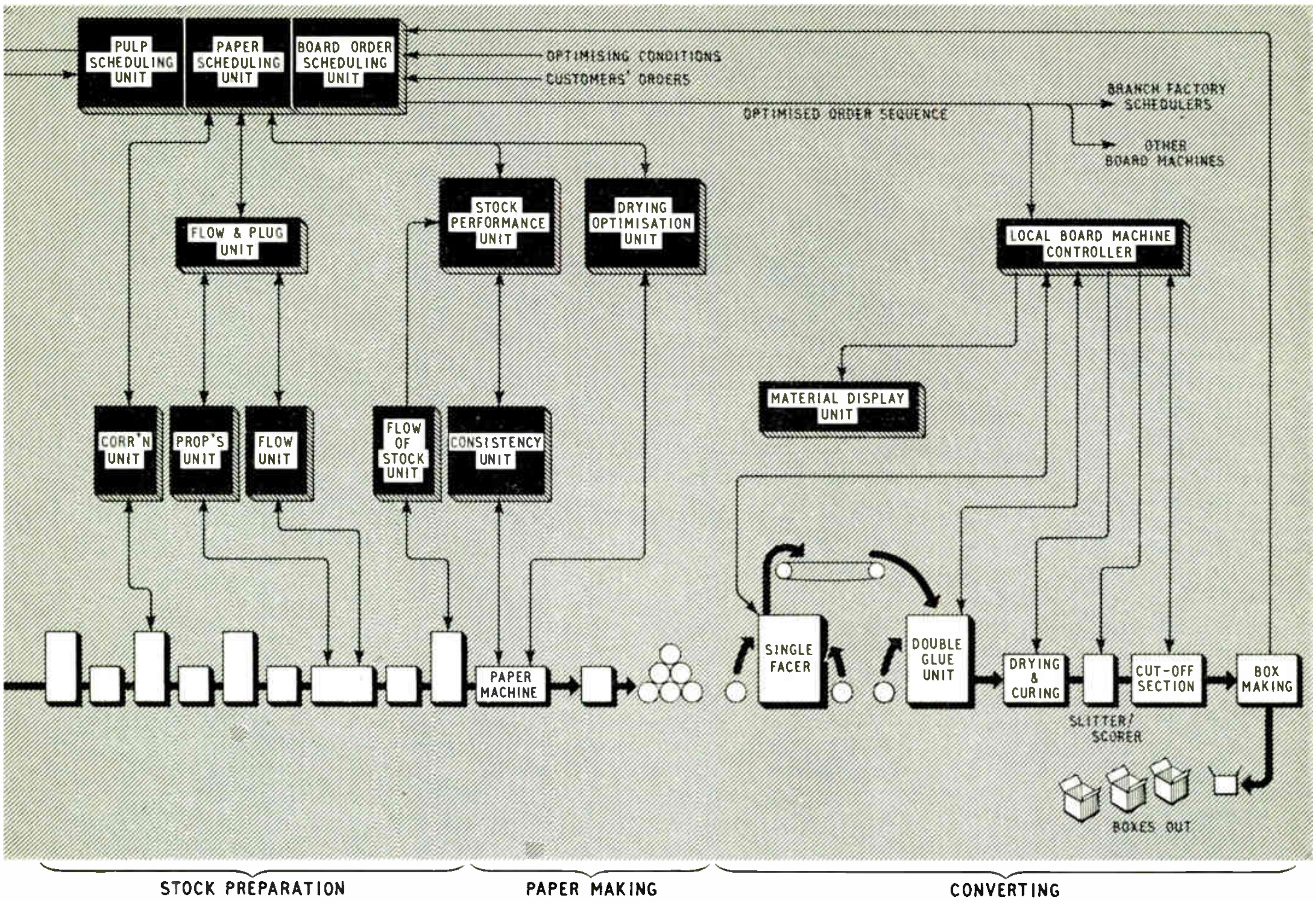
An extension of this approach, however, is feasible. This is based on the human organization structure universally adopted in activities of all kinds. Such a structure consists of a number of echelons extending downwards from top management. Since the volume of detailed information invariably increases in going from a higher to a lower echelon the number of staff populating the lower echelon is invariably larger. The structure therefore has the form of a pyramid. A structure of this kind drawn up for management purposes will usually reflect the flow of information but it stops at the lowest human echelon and does not show the detailed penetration of information flow into the process plant itself. Include this and in effect the complete works information mesh is defined.

Looking at such a structure it can be seen that if each unit in each echelon can be replaced by special purpose computing equipment a situation of complete automation can eventually be reached.

The approach has far-reaching advantages. Each part is put in for its specific purpose as it becomes possible to define it and can immediately be used by itself. Development proceeds in step with knowledge of the process and with production needs and capital is invested gradually. At no stage is there incorporated more equipment than can be usefully used to get immediate production improvements. Moreover the changing pattern of requirements allows modifications to the system with relatively small expense and the system can be easily understood by engineers and managers not necessarily steeped in the computer art.

In the belief that this approach was right, Elliott-Automation have evolved hardware in keeping with it. The result is the system called Arch. Its application may be illustrated by a description of its use in an integrated works for the production of corrugated board box flats from the basic raw material wood.

The diagram shows the individual process units involved—there are many of them. Starting with raw timber it is cut up, debarked, turned into chips or even smaller particles and fed into storage hoppers to be weighed out and charged to the digester. Here it is converted to sulphate pulp and after a number of further processes stock is produced to be fed to the fourdrinier paper machine. The wet paper is dried and in the form of Kraft is fed to the board-making machine where a corrugated sheet is first prepared. To this a further sheet is glued to each side to make a board. The finished board must be cut into appropriately sized sheets, slit up, fold markings and appropriate printing to customer's requirements added and finally a stack of flat sheets (box flats), for folding into a finished box, is shipped.




Let us look at the process for the manufacture of pulp. Here the digester is the central process plant. In it wood is cooked to remove lignin so as to end up with a precise ratio of cellulose to lignin.

Imagine now that you are the manager of this plant. You are aware that your output rate is not up to the maximum possible. Your quality is variable. You are wasting some of your valuable raw material and you are probably not getting optimum cooking conditions so that you are using more steam than is really necessary. You know that at the moment your product costs about £1·5 million annually to produce so that even a net improvement of 1% saves £15,000 annually. You have been offered a general purpose computing machine solution to your control problems, but at a cost of about £100,000 you cannot entertain the 6-year pay-off, nor are you convinced it will be effective.

Successful operation of the process you manage depends on doing three things correctly. First, the digester vessel must be charged with the right amount of wood. Secondly, it must be charged with the correct amount of chemical solution. Thirdly, with the lid closed the contents must be heated up gradually to a certain temperature, maintained at this temperature for a time and then cooled down at a certain rate.

Let us look at these operations separately. The wood supply is contained in a number of hoppers. It is moist wood. However, it is the weight of wood and not wood plus moisture that is important in charging the digester. At the moment your operators estimate the corrections required. But a system of moisture measuring instruments and accurate electrical weighing equipment can provide all the necessary information to a computing unit to calculate the dry wood weight to be fed to the conveyor, and control matters so that the exact weight of effectively dry wood is fed to the digester.

The various computing operations of addition, subtraction and so on needed to perform this calculation can be carried out by the Arch wood-weighing and moisture unit in the diagram.

The introduction of this is the first step in automation and having proved it in practice you now think about the chemical loading. Here you are charging caustic soda solution—known as white liquor—together with some liquor from a previous cook—known as black liquor. The preparation of each liquor must be controlled accurately and related to the dry wood weight of the charge. At the moment you are in difficulty because, of course, the moisture present in the wood is considerable and will dilute the liquor. However, your Arch unit has a memory in which it has retained the measurement of the moisture content of the wood charge.

So now you consider a further computing system which makes use of this moisture content figure and computes the precise quantities of white and black liquor to be charged. Furthermore, it exerts a control on the inlet valves so that the right amounts are, in fact, put in. This is shown in the diagram by the Arch liquor proportioning unit.

Two steps towards complete automation have now been achieved and the process can be continued step-by-step until the complete automation indicated by all the Arch units in the figure is obtained.

**For further information circle 36 on Service Card**

# Semiconductors in industry

To the uninitiated, semiconductors or transistors mean small portable radios that make a noise on the beach, but in fact semiconductors have brought tremendous advantages to the industrial user of electronics. This article briefly outlines the operation of semiconductors and indicates a number of ways in which they are being used.

TO many people the word electronics still conjures up the picture of rows of more or less brightly lit thermionic valves, of delicate glass bottles which are always going wrong. This is a complete travesty of the real state of affairs. Modern thermionic valves are extremely reliable and their expected life is measured in many thousands of hours of operation. They are even used in submerged repeaters in submarine cables, where they are expected to last for at least 20 years of continuous operation!

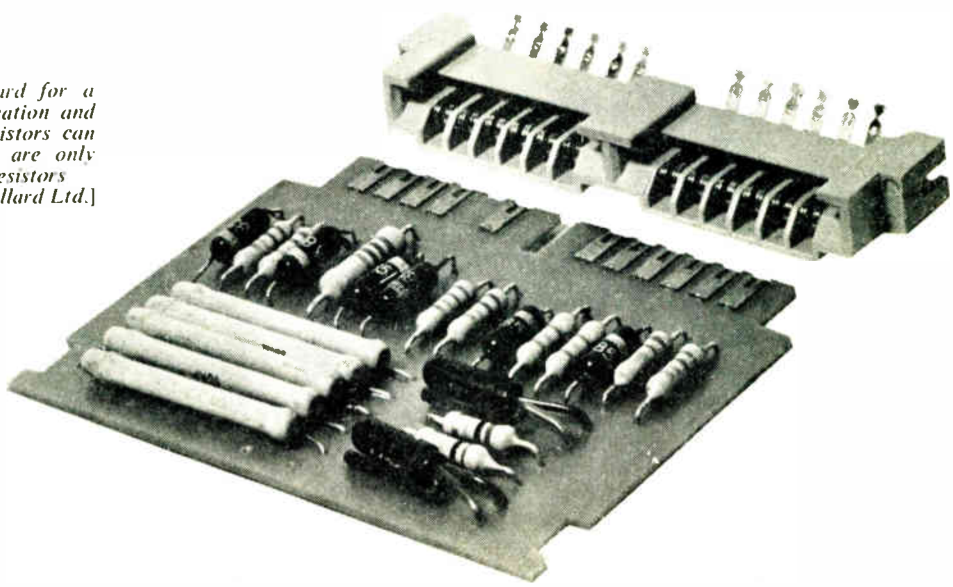
In spite of the fact that the valve is now quite reasonably reliable, it is rapidly being displaced for a great many, but not all, applications by various semiconductor devices. Two-terminal devices have been in widespread use for many years as rectifiers. Copper-oxide rectifiers were developed in the late 1920s and about ten years later selenium rectifiers were produced.

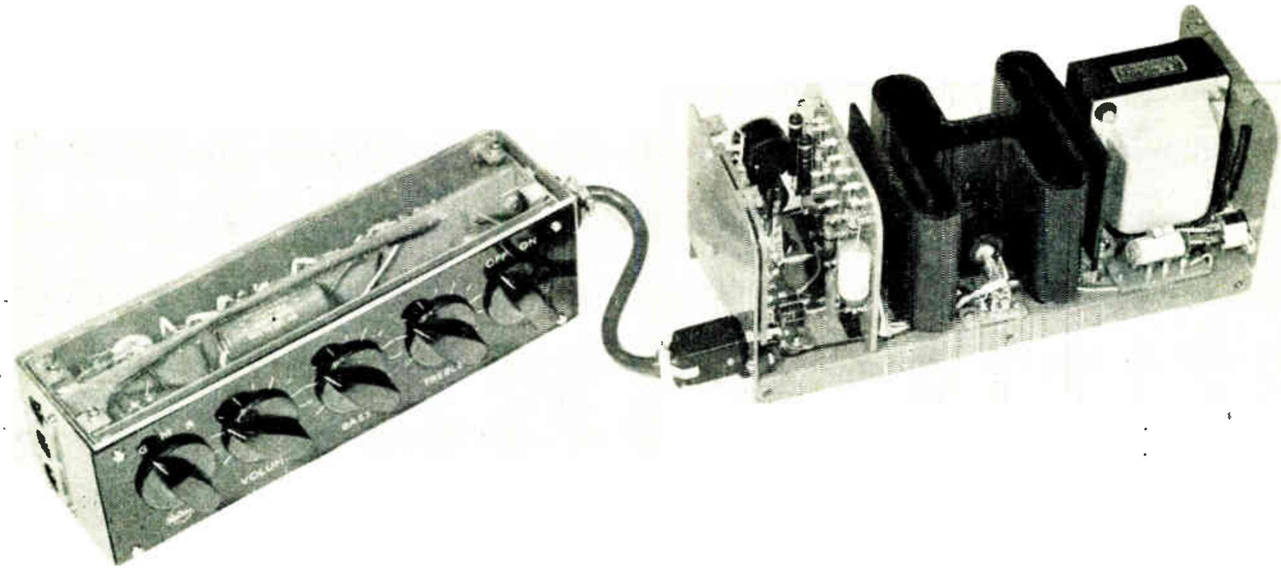
These older forms of semiconductor are still widely used, but they are not what is generally meant when semiconductors are referred to. The modern types date basically from the invention of the transistor in 1948 and usually employ either germanium or silicon as the basic material. New types are being developed almost every day, but the most widely used are ones which perform functions very similar to those of thermionic valves. Two-terminal types are mainly rectifiers or voltage stabilizers; three-terminal types are amplifiers or switches.

The two fundamental differences between valves and 'equivalent' semiconductor devices are that the latter need no cathode-heating power and they are of much lower impedance. They operate at a relatively low voltage and high current.

They also have the practical advantages that they are solid

*A plug-in printed-circuit board for a remote control, remote indication and telemetry system. Two transistors can be seen near the front and are only slightly larger than ordinary resistors*
[*Courtesy Mullard Ltd.*]






*An experimental high-quality audio amplifier and pre-amplifier using transistors. One of the power transistors can be seen in the right-hand unit mounted on heavy metal work. Although larger than low-power transistors the high-power types are still small. The heavy metal work is needed to remove heat quickly from the transistors*

[*Courtesy Mullard Ltd.*]

devices; there is no structure of spaced electrodes. They are, therefore, much more robust, and they are physically very small.

The starting point in, say, transistor construction is germanium (or silicon) in an extremely pure state; it is commonly called intrinsic material. It is intermediate in its conducting properties between an insulator and a metal. Its characteristics can be modified by adding very small amounts of carefully controlled impurities. These greatly increase the conductivity over that of the intrinsic material but, more important, they can do so in two different ways. One kind of added impurity can make the material conduct mainly by means of electrons: these are negative charge carriers and are responsible for the conductivity of metals and, of course, of thermionic devices. A material with this kind of impurity is called n-type because there are *n*egative charge carriers.

A different impurity makes the material behave as if there were *p*ositive charge carriers, and it is consequently spoken of as p-type material. Physically there are no such charge carriers, and the behaviour of the material is determined by the absence of some electrons from the atomic structure of the material. These places where electrons are missing are known as holes. If a hole happens to get filled by an electron it disappears, but the electron which has entered a hole to fill it has itself left a hole somewhere else in the structure. Although one hole may thus disappear another appears somewhere else, and so the hole appears to have moved. As a hole represents a place without its normal electron, the absence of the negative charge of the electron means that the hole has positive charge.

A hole thus behaves as if it were a positively charged particle. The 'hole' concept is a very useful one and enables many aspects of semiconductor action to be explained in an understandable sort of way. It is only a kind of analogy to the real action, however, but it does not seem possible to explain this real action without going quite deeply into quantum mechanics!

The basic transistor is a sandwich of two layers of one kind of material with a layer of the opposite kind between them. Usually p-type is used for the outer layers with n-type between them; but they can be the other way round. The first is called a p-n-p type, the second an n-p-n.

The n-p-n transistor is closely analogous to the thermionic valve as far as the external circuit is concerned. The collector (anode) has a voltage applied to it which is positive with respect to the emitter (cathode), just as with a valve, and the current flows in the same direction as with a valve, being prescribed by the supply-voltage polarity.

The p-n-p transistor, on the other hand, requires that the collector be negative to the emitter. The power supply voltage and the circuit direction of the current are thus reversed. This is actually the most usual type of transistor.

In one way of making a transistor the starting point is a melt of intrinsic germanium. To this the proper amount of p-type impurity is added. A seed crystal is dipped into the melt and gradually withdrawn at the proper rate as a new crystal of p-type germanium grows. When this has grown sufficiently an n-type impurity is added to the melt in sufficient quantity to over-neutralize the p-type impurity and make the whole melt n-type. The crystal still continues to grow but now with n-type material. When this has continued sufficiently, more p-type impurity is added to turn the melt back to p-type and the crystal continues to grow. There is thus produced a layer of n-type material between two layers of p-type. The whole is a single crystal having different impurities as the layers.

The crystal is then sawn into slices, polished and etched and connections are made to the layers.

There is a lot more to transistor production than this and there are a good many different ways of making them. Some transistors, even, do not have a layer construction. In every case, however, the different regions exist in a solid material; they may be produced by a growing process or by an alloying, but the transistor itself is a solid thing and very robust.

It requires subsequent encapsulation for protection, since surface contamination can seriously affect it. It is, moreover, sensitive to light and normally the encapsulation must be opaque. The effect is put to use in photo-transistors, however, which in some applications can replace other forms of photocell.

All semiconductor devices are sensitive to temperature. This again can be a useful property, but is more often a disadvantage. Much can be done in the associated circuit design to minimize the effects of temperature, but there are fundamental limits. Germanium semiconductor devices are commonly intended for use at ambient temperatures up to about 50 °C and cannot often be safely used at much higher temperatures. Silicon devices, however, can be used up to at least 70 °C but are usually more expensive.

Two-terminal devices, diodes, are very widely used as rectifiers; the silicon rectifier, in particular, is finding wide application for rectifying alternating current to give a d.c. supply for traction motors. Four-layer devices give characteristics analogous to those of a thyratron and are used, say, for rectifying a.c. and at the same time giving a controlled output for motor-speed control. This is done by feeding a.c. to a control electrode and varying its phase relative to the main supply, much as is done with the thyratron.

Transistors, the commonest three-terminal devices, are mainly used to perform functions which could in principle be equally well carried out by thermionic valves. Being solid-state devices, they are mechanically much more robust than valves. They are also more efficient in that they need less power from the supply for a given output. This is partly, but only partly, because they need no cathode-heating power as valves do; they are intrinsically more efficient. However, this greater efficiency is of most importance in rather extreme cases. It is very important in computers where many thousands of the devices are used, for the reduced power needed not only saves money directly but reduces the heat produced and so makes it unnecessary to provide such elaborate cooling apparatus. It is also very important in portable apparatus or wherever the power must come from batteries. The commonest everyday example is the ordinary transistor portable radio set; transistors have enormously improved this for not only is the performance much better than that of a valve counterpart but the running costs for batteries are much lower. The hearing-aid is another and more important example: the miniature aids now common would be quite impossible without the transistor. In conjunction with miniaturization techniques it has made possible much of the communication and telemetry equipment fitted to artificial satellites.

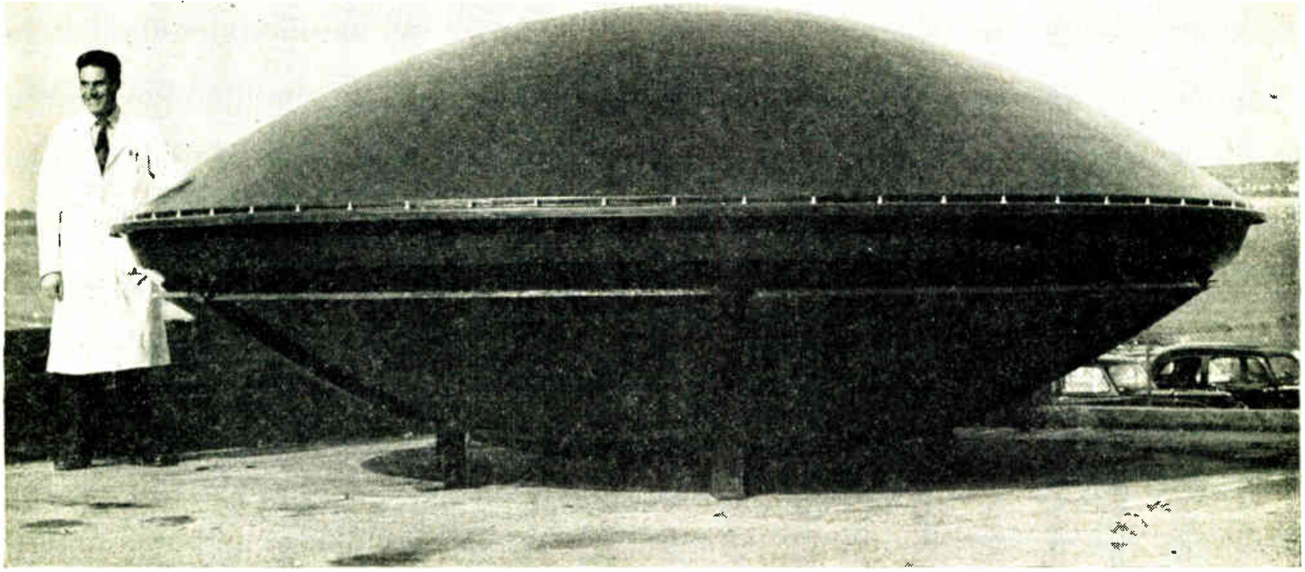
The intrinsic efficiency of semiconductor devices becomes of importance at the other extreme of the power scale, however. It is largely responsible for the rapidly increasing use of the silicon rectifier. When the power involved is high enough, quite a small improvement in efficiency represents quite a big saving.

At present, the thermionic valve is still supreme as a generator or amplifier of high power and especially at high frequencies. Transistors can generate power up to at least 1,000 Mc/s but only at very low power levels. Even at comparatively low frequencies of a few tens of kilocycles they are limited to powers of a few tens or hundreds of watts. The valve is also supreme in applications where a very high input impedance is essential, for example, in pH meters.

There are certain fields where the valve must be used: there are some others where it is better to use valves than transistors. There is a very broad field of application where either can be used, but the greater ruggedness and smaller size of the transistor are making it the preferred element. And finally, there is a very special field where the transistor reigns supreme and enables things to be done which could not be done at all with valves.

As semiconductor development proceeds there is no doubt at all that the applications for which valves are now necessary or desirable will shrink further. It will still be a long time, however, before the valve disappears; it may well always have its proper sphere.

## Large Dish Aerial



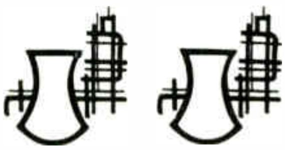
*A large radar aerial constructed by English Electric Aviation. The dish aerial has a metallized parabolic reflecting surface with a supporting structure of honeycomb sandwich construction, using polyester glass skins. The unit has a radome cover of similar construction. The wall thickness and electrical properties of the radome are controlled to close limits to produce maximum transmission and minimum distortion of the signal*


# TRAD? NOT THE ELLIOTT 503!

## The 503 - what can it do?

This, of course, is another 'How long is a piece of string' kind of question. Even the designers of a computer can't hope to predict all, or even many, of the uses to which it will be put. And in the case of such an extremely fast and versatile machine as the new Elliott 503, it is even more difficult to be specific about its applications.

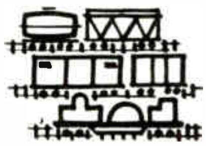
The examples given in this leaflet, therefore, are merely some of the more obvious of today's problems for which the 503 is destined to provide the solution.



**Operational Research and Process Optimisation.**

STRATEGY: The operational research techniques of war-time strategy have been extended for use in industrial operations, in order to find out the best way of doing a job. Application of these techniques demands extensive resources for the automatic processing of the data involved. In short—the 503.

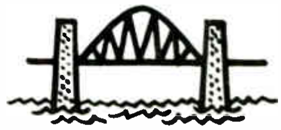
TACTICS: On the tactical level of optimisation—effect-wise, quality-wise, quantity-wise, and cost-wise—of the individual processes of an operation, much effort is at present being spent on hill-climbing procedures based on trial-and-error evaluations. A machine like the 503—which will itself make all the necessary proposals, evaluate and select the best one—accelerates such operations, and reduces the risk of human error.



**Linear Programming and Scheduling.**

Computers are being increasingly used for scheduling operations in industrial and administrative fields.

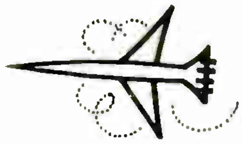
Scheduling the distribution of products and the transport which carries them, compiling railway and airline time-tables, and studies in traffic control—these are some of the tasks in this field which require a high-speed computer. The moderately priced 503 will undoubtedly find many applications here.



**PERT – Programme Evaluation Review Technique.**

A recent interesting development in the use of computers has been for the evaluation of a manufacturing or construction programme in terms of materials, labour, time duration and sequence of component activities etc. The computer will compare all the possible alternative programmes, select the best, and control the progress of the selected one.

The 503, with its large rapid-access working store and high computational speed is eminently suitable for this work.



## Aircraft Design and Construction.

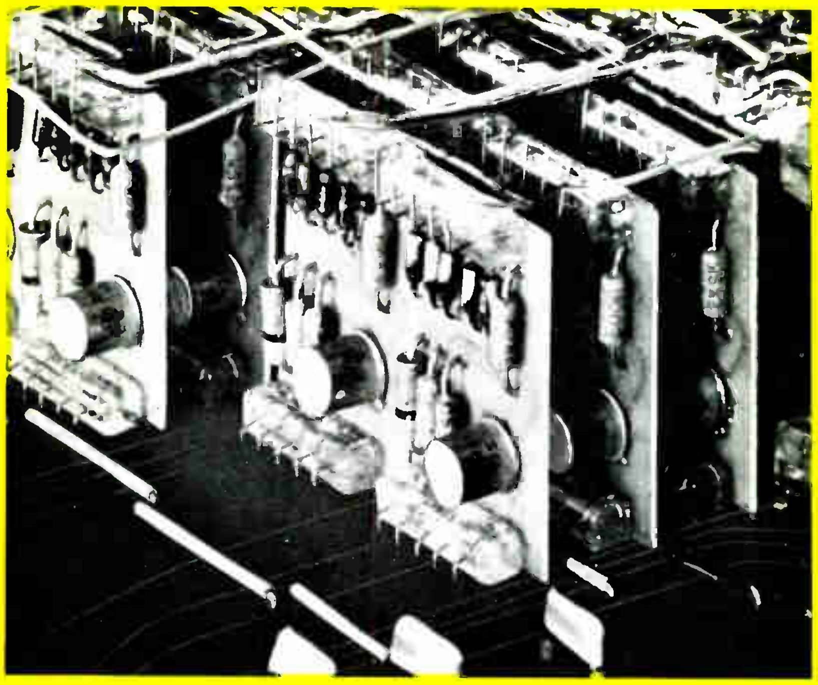
Computers are indispensable in many branches of mechanical and structural engineering, perhaps the most obvious of which is that of aircraft design. The high speed jets and guided missiles of today could not possibly have been designed without the use of computers.

The more revolutionary aircraft of tomorrow present even greater problems for the computer to solve. The effects of kinetic heating, the behaviour of new and hitherto untried materials and constructional

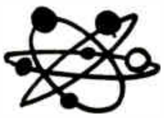
# 503 ELLIOTT

### 503 TECHNICAL SPECIFICATION

- *Central processer contains a working store of 8192 words, cycle time 3·3 microseconds.*
- *Fixed-point words are 39 bits.*
- *Floating-point words are 30 + 9 bits.*
- *Two single-address instructions per word.*
- *Input is 1000 characters a second.*
- *Output is 100 characters a second.*
- *Paper tape is 8-track.*
- *Interrupt Control Unit for time-sharing is optional.*
- *Peripherals include backing core store up to 131 072 words, fast tape, slow tape, card in, card out, and 1000 line-a-minute printer.*
- *Fast arithmetic unit averages 100 000 operations a second.*
- *ALGOL compiler and Symbolic Assembly Programme simplify programming.*
- *Full library includes Mark 3 Autocode and Matrix Interpreter.*
- *Takes all 803 programmes.*
- *Basic pulse rate is 6·7 megacycles per second.*



techniques, and, on the operational side, route study and air traffic control—these are some of the many such problems which the 503 will take in its stride.



**Nuclear Engineering and Research.**

Even more complex than the computational problems of the aircraft designer are those of the nuclear scientist. Nuclear engineering and research will always demand computers with enormous capacity for rapid and accurate solution of the tremendous problems involved.

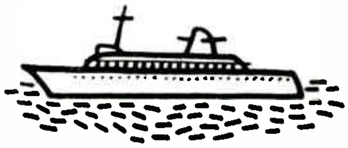
Thermonuclear plasma investigations are currently absorbing a significant part of the total effort of the Atomic Energy authorities of this and many other countries.

The need to understand the physics of solids is of great importance in all work on the materials used in nuclear reactors, including the fuel elements, the moderators and the structural materials. To predict the behaviour of these materials in the severe conditions of temperature and irradiation in a reactor again requires very extensive calculation.

For solving these, and many other problems of nuclear science, the 503 is the ideal machine.

**Road Planning and Traffic Analysis.**

The construction of roads and motorways—now rapidly accelerating in this country—is another brand of engineering that requires high-speed computers such as the 503. At the same time, however much our roads and motorways improve, with the continual increase in traffic our traffic problems increase yearly—all the greater is the need for machines like the 503! Traffic analysis and the relief of congestion, whether on a wide-scale or local basis, is yet another activity within the scope of this most versatile computer.



**Shipbuilding.**

Here is yet another of our important national industries which has already benefited by the introduction of computers, but could still benefit considerably more. Particularly, a lot of work is still to be done modernising the techniques of hull design. Here is one of many similar jobs in shipbuilding which call out for a computer with the capabilities of the 503.

## Anything else

Yes, of course. These are only a handful of the many varied fields of science, industry, engineering, or administration in which the 503 is destined to play a major role. There are many others.

Weather forecasting, census evaluations, crystallography and structural chemistry, language studies, numerical taxonomy, problems of astrophysics, cosmology and fluid dynamics . . . the list is practically endless.

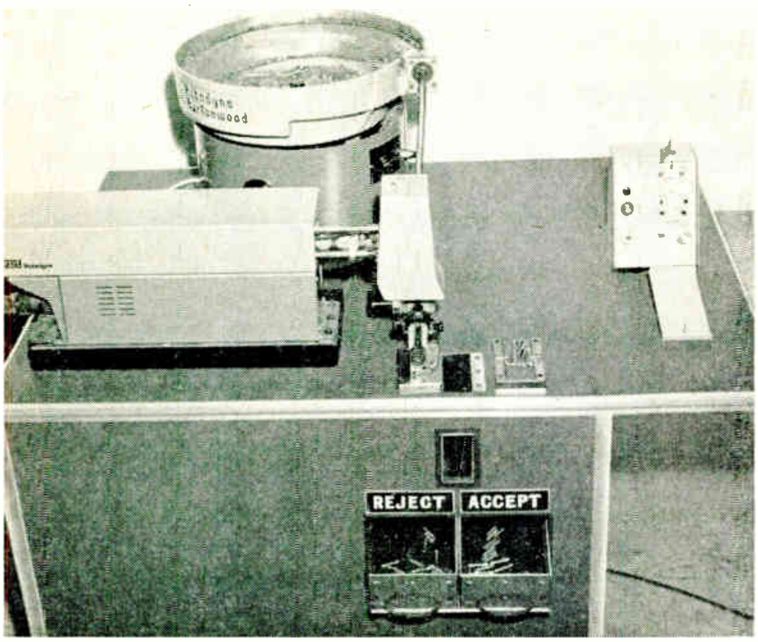
This is why it is impossible to answer comprehensively the question "What can the 503 do?". The more it is asked to do, the more it will.

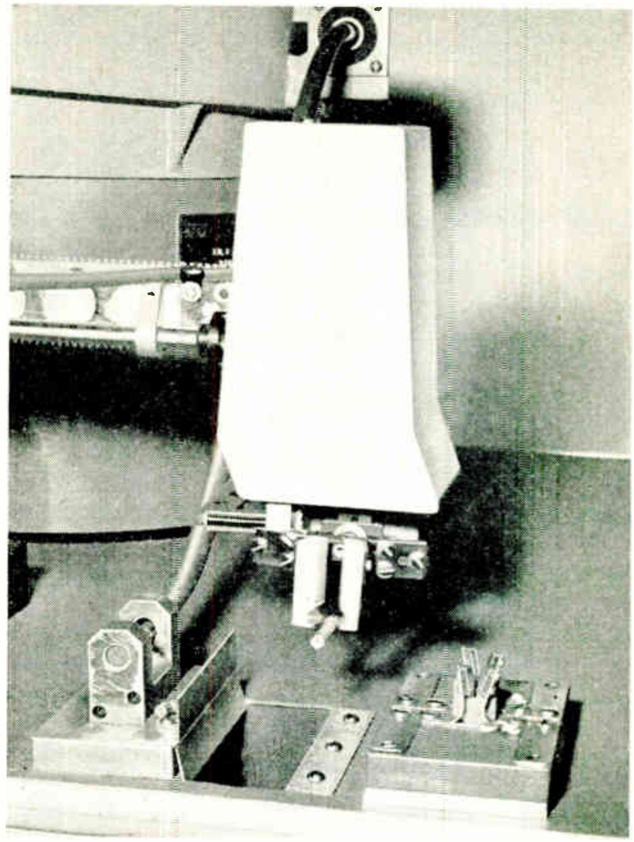
ELLIOTT

*For further details and information, contact:—*

ELLIOTT COMPUTING DIVISION, ELLIOTT BROTHERS (LONDON) LIMITED, BOREHAMWOOD, HERTFORDSHIRE

*A member of the Elliott-Automation Group.* EA

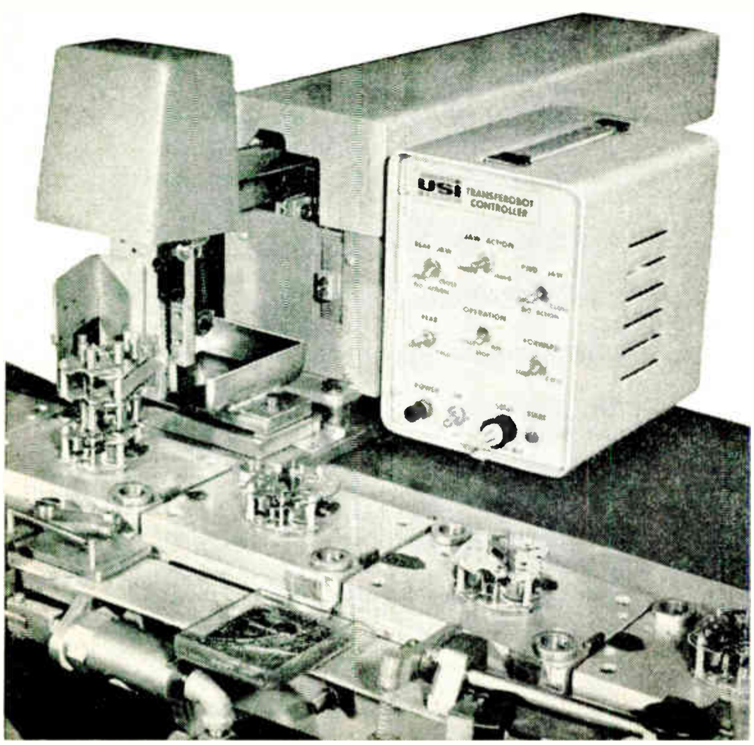


*Above: Fig. 1. Fuse-testing machine. The fuses are put into a vibratory feeding bowl which delivers them down a chute*

*Above right: Fig. 2. The jaws of the machine pick up each fuse in turn and hold it against the contacts on the right for test and then release it down the appropriate chute*

*Below: Fig. 3. A TransfeRobot with a special controller used for oiling clock bearings*




# TransfeRobot

THE PHOTOGRAPHS illustrate equipment for the automatic testing of fuses. In the apparatus, developed for Brush Electrical Engineering Co. Ltd., a vibratory feeding bowl delivers fuses down a chute to a TransfeRobot 200, shown in Fig. 1. The jaws of the machine, Fig. 2, pick up each fuse, hold it against electrical contacts to test it, and then release it down the appropriate chute—accept or reject.

The TransfeRobot is readily adaptable for other routine assembly tasks, for its possible movements are controlled by transistor circuitry and it can easily be set up to carry out a different programme.

Fig. 3 shows it, with a special head, being used to oil complete clock assemblies. In this application it oils eight bearings simultaneously every second. It can in fact be employed for any operation which requires that an object be picked up and transferred to another position. The horizontal stroke is from 3 in. to 10 in. and the vertical from $\frac{5}{8}$ in. to 2 in.

The machine is dealt with by U.S. Industries Inc. (Engineering) Ltd., and this firm is setting aside a portion of its profits on each machine to a trust fund which is being set up in this country. The purpose of the fund is to finance a study of the effects of automation and of ways of re-training workers in automation techniques.

**For further information circle 37 on Service Card**

Radioactive material is now widely used in industry for measurement purposes. This article describes some of the common processes.

# NUCLEONICS AND INDUSTRY

**By DENIS TAYLOR, Ph.D., M.I.E.E., F.Inst.P.***

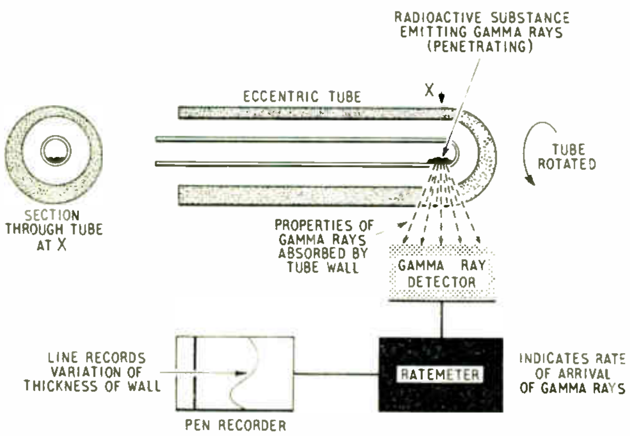



*Fig. 1.—General arrangement for measuring the eccentricity of large diameter tubing. The absorption of gamma rays varies with the thickness of the tube wall*

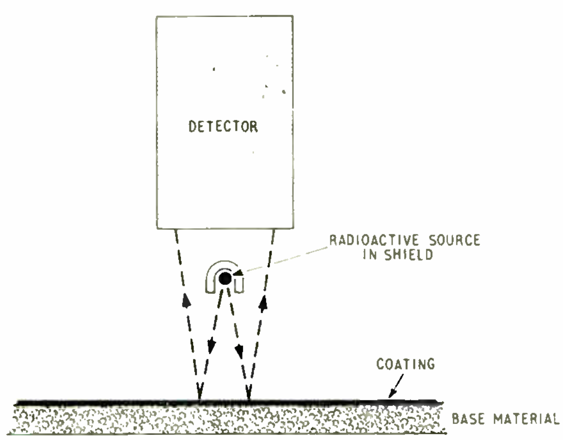



*Fig. 2.—The thickness of a coating on a base material can be measured from one side using β particles*

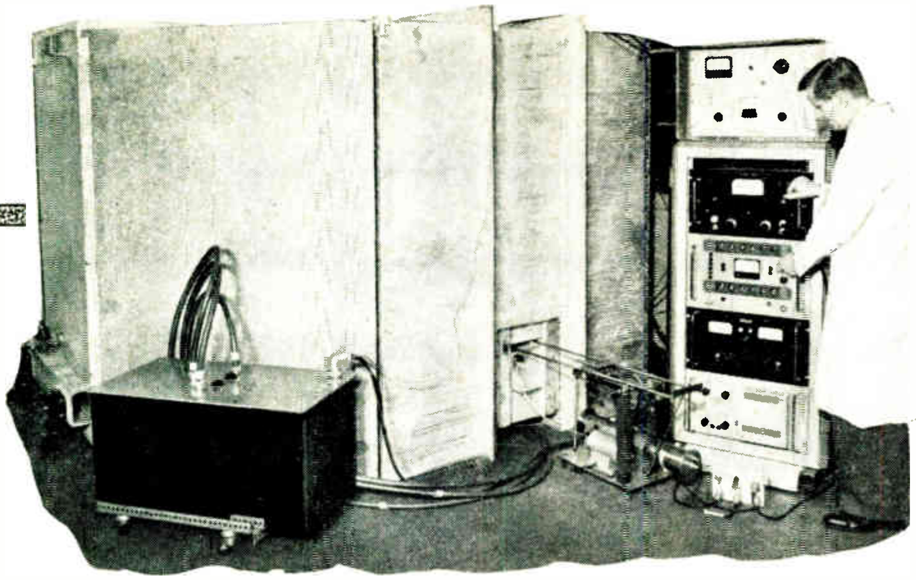
ATTENTION has been called many times to the large financial savings afforded to industry by the use of radioactive materials. The applications now cover a very wide field, e.g. measurement of thickness of materials during manufacture; level indication in enclosed pipes, tanks and packages; assessment of bulk flow and mixing in production processes; the elimination of static electricity in the weaving of textiles; the study of wear in machinery; the detection of leakage in oil and water pipe lines; the inspection of boreholes to study underground strata in coal and oil prospecting; the radiography of castings and welds as a supplement to X-ray inspection. Highest on the list of applications are all types of gauges, followed by applications to the oil industry, but new uses of nucleonic techniques are being developed continuously. Altogether the savings to industry resulting from the use of these techniques have been estimated as over 300 million dollars in the United States alone.

## Uses of Nucleonics in Gauging

The most commonly used instrument is the thickness gauge. A radioactive material emitting α-particles, β-particles or γ-radiation is employed, together with a suitable detector which will respond to this radiation (α, β, or γ as the case may be). The amount of radiation impinging on the detector depends on the amount and kind of material put in its way, so that the thickness or the density for example, can be quickly and accurately measured.

Radioisotopic sources are available which emit α-particles, which are charged helium nuclei and are completely stopped by a piece of paper; β-particles which are high velocity electrons and can penetrate up to an eighth of an inch of aluminium; and γ-rays which resemble X-rays and can penetrate several inches of steel. It, therefore, follows that a wide range of materials and thicknesses can be usefully examined by such sources in combination with the appropriate detector. No contact is made with the material, as is the case with conventional methods of measuring thickness, a continuous estimate can be given, and the measurement is in the form of an electrical signal which can be used to adjust operational machinery automatically as the process is carried out. Consequently, the material is consistently produced to a more strict specification.

* Director, Plessey Nucleonics Ltd.



*Experimental apparatus for the measurement of oxygen in steel*
[*Courtesy Plessey Nucleonics Ltd.*]

Thin materials, such as metallic foil, plastic sheet and varnished paper are controlled in this way using $\beta$-radiation, whereas $\gamma$-radiation is used in the heavy industry, for example in the control of strip metal production in the rolling mills. Apart from the straightforward application of monitoring the thickness of plates, nucleonic techniques can be employed for a number of special purposes. A specific case is the detection of eccentricity in the production of large diameter tubing used in making gas cylinders. This is illustrated in Fig. 1. The radioactive source is introduced into the tube, and as the tube rotates any eccentricity shows up as a varying response to the detector system due to the variation of attenuation, due, in turn, to the variation of the amount of metal between the source and detector.

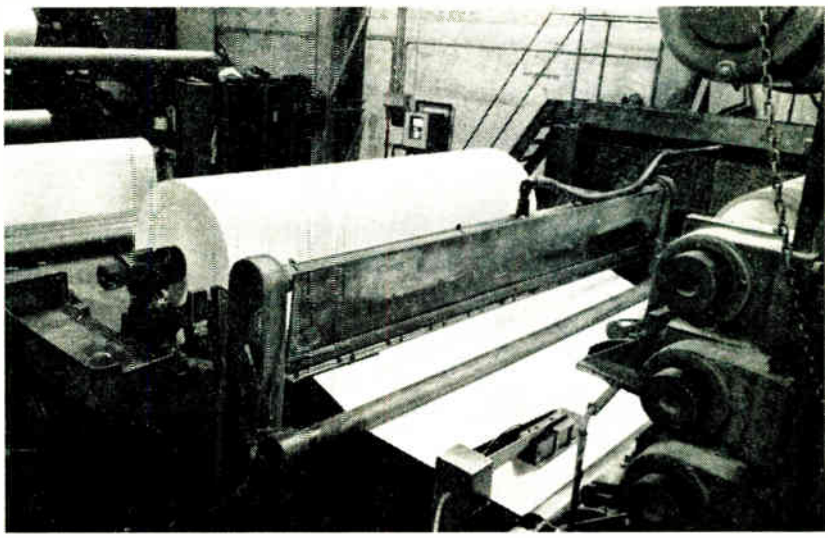
Apart from the transmission type of gauge, backscatter or reflection gauges are also employed. This method is particularly applicable to the measurement of a coating on a base material. It is also applicable when only one side of the material can be approached. A good example of the latter is an oil pipe-line where corrosion spots can occur inside. The method depends on the use of a radioactive source (a gamma source for the oil pipe-line) and a detector head which are clamped to the pipe. The response of the detector depends on the amount of metal backscattering the radiation, and so corrosion spots (due to the thickness of the metal at such points) are shown up by the reduced signal obtained.

Fig. 2 illustrates the backscattering of $\beta$-particles for the measurement of a coating on a base material. In tin-plating mills a coating of a few thousandths of an inch can be quickly and accurately measured.

Nucleonic gauges are gradually being used on an increasing scale, but progress has not been as rapid as would be expected bearing in mind the saving and more efficient production which their use allows. A part of the difficulty is that associated with the introduction of radioactive materials into industrial premises are the attendant health hazards. For these applications, however, the radioactive sources can be sealed in a container, so that there is no danger of the radioactive material becoming dispersed. Secondly, shields and other protective measures can be introduced to prevent factory operatives from approaching dangerously close to the radioactive sources.

On the economics side, several American companies have

*The photograph shows $\beta$-radiation apparatus measuring paper thickness by absorption*
[*Courtesy E. K. Cole Ltd.*]



# SPUTTERED COMPONENTS IN THIN-FILM CIRCUITS

By P. LLOYD, A.M.I.E.E.*

**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.**

REFRACTORY metals and their oxides having desirable resistive and dielectric properties cannot be produced in the form of thin films by the normal methods of vacuum evaporation; fortunately their deposition can be achieved by means of cathodic sputtering.

This technique, older than evaporation methods, was first discussed as long ago as 1852[1], and is finding increasing application where the deposition of thin films of the high melting point elements in atomic groups IV and V is required. Of particular interest in this category are tantalum, niobium and titanium. A recent paper by M. Koedam[2] contains an introduction to cathodic sputtering and an extensive literature survey.

### The Sputtering Process

A typical sputtering apparatus is shown diagrammatically in Fig. 1 and the process may be briefly described as follows.

After an initial pump down to $10^{-5}$ mm Hg, argon is admitted to the chamber via a needle valve to give a working pressure of $2 \times 10^{-2}$ mm Hg. On the application of high voltage to the electrode system, which comprises a cathode of the material to be sputtered and an anode arranged as a work support, ionization of the gas takes place forming a glow discharge. The positive argon ions from this discharge

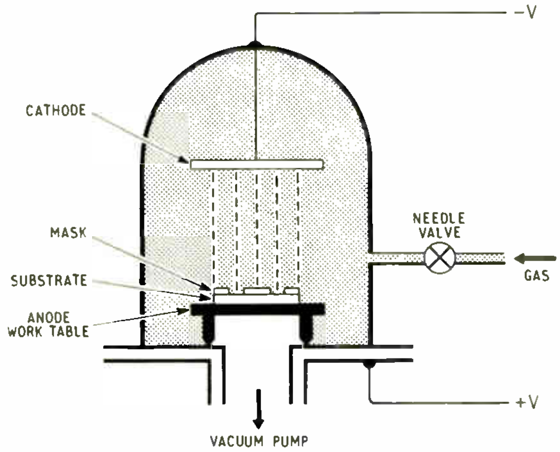



*Fig. 1.—General arrangement of the sputtering apparatus. The cathode is of the material to be sputtered*

bombard the cathode; the removal of atoms from the cathode surface then takes place by exchange of momentum. The sputtered material diffuses through the cathode–anode interspace to deposit on the chosen substrate, which is normally placed in contact with the surface of the anode. For the preparation of experimental film samples the substrates employed are either glass or fused quartz microscope slides.

When the sputtered film is required to conform to some definite pattern, as for example in the case of a meandered resistor, a mask with the correct configuration is placed in intimate contact with the surface of the substrate.

### Resistors

The metal tantalum, although normally met with in the electronic components field as the rolled foil in an electrolytic capacitor upon which a dielectric film has been formed by anodization, is also of considerable interest as a resistive element. Highly adherent to glass, without the need for seeding layers, sputtered tantalum films are corrosion resistant by virtue of their oxide surface layers. Stable films have

* Royal Radar Establishment.

been measured[3] up to 768 ohms per unit square with a temperature coefficient of less than 0·0001 per °C. In the period immediately following deposition these films show an increase of resistance due to oxidation effects and it is necessary to stabilize them[4] by heating in air for a period of an hour or more at 250 °C. This aging temperature is chosen to be well above that at which the resistor is required to operate.

With apparatus similar to that described above, using a potential of 2·4 kV and a cathode-current density of 0·2 mA per $cm^2$, the writer has obtained a deposition rate for tantalum of 80 Å per minute.

### Capacitors

If, as a modification to the sputtering process, the glow discharge is set up in oxygen, instead of an inert gas, there is a chemical combination of the metal atoms with the residual atmosphere and the oxide of the cathode material is deposited as a film instead of the metal. By employing a tantalum cathode and sputtering with oxygen ions a layer of tantalum pentoxide ($Ta_2O_5$) can now be formed on the substrate. This oxide, well known for its stable properties as a dielectric in electrolytic capacitors, can by virtue of this 'reactive' sputtering process be utilized as a dry dielectric in thin film capacitor structures.

The preparation and general properties of capacitors of this type have been described previously[5]. Recent measurements indicate that a capacitor of 0·015 $\mu$F, 0·1 sq cm in area, would have a leakage current of $10^{-9}$ amp at 4·5 V. The dielectric film thickness in this instance would be approximately 1,000 Å. Dissipation factor (tan $\delta$) is 0·005 at 1 kc/s. Subsequent heat treatment of the films has given an improvement of one order in values of dissipation factor and leakage current.

### Sputtered Components as Circuit Elements

In order to demonstrate the possibilities of sputtered resistive and dielectric films a free-running multivibrator oscillator (p.r.f. of 2·6 kc/s) was constructed on a 3-in. × 1-in. substrate with sub-miniature transistors type OC331 as the active elements. Fig. 2 is a photograph of the substrate showing the symmetrical disposition of the components.

At each end of the substrate is a meandered 27,000-Ω bias resistor, the two 1,000-Ω collector loads are the single lines disposed about the centreline. The 0·01-$\mu$F capacitor electrodes are positioned at right angles to each other and in the vicinity can be seen the extreme edges of the dielectric film. Interconnection of the components has been arranged by the use of evaporated aluminium strips which also serve as capacitor electrodes. The transistors are connected by flying leads to small solderable areas of evaporated manganese-nickel-copper alloy which also serve as terminations for output and battery leads.

### Demonstration Oscillator

To provide an audible and simple indication of operation the substrate as described above was provided with a small loudspeaker, which was connected, in a somewhat unorthodox manner, in series with the emitter of one transistor.

The completed assembly was mounted in a Perspex container and Fig. 3 is a photograph giving a general view of the exhibit which was shown at the I.E.A. Exhibition (Olympia 28th May–2nd June 1962). The theoretical circuit diagram is given in Fig. 4.

### Future Developments

Sputtering techniques, because of their application to the deposition of refractory metals and oxides, are not only of interest in the further development of thin film passive

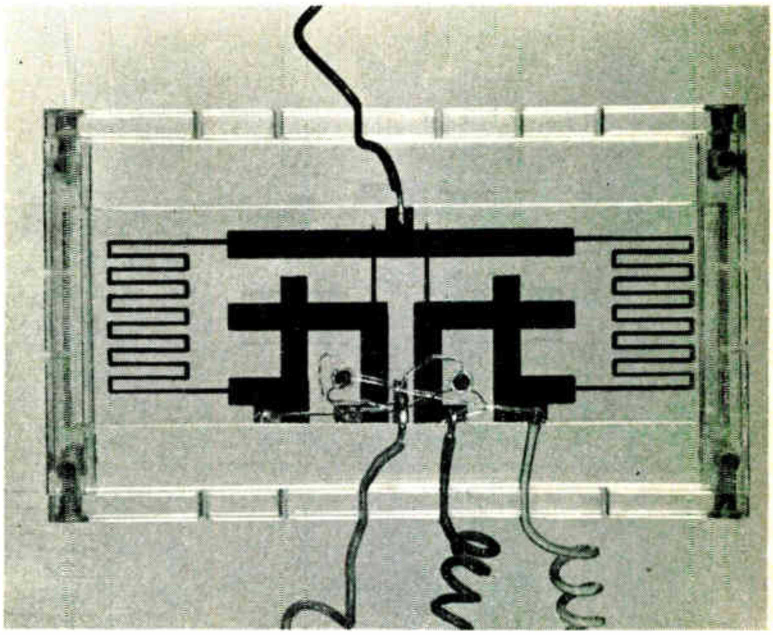


*Fig. 2.—Experimental multivibrator with sputtered resistors and capacitors. The transistors are soldered in place*
[*Crown copyright*]

*Fig. 3.—Demonstration model of multivibrator*
[*Crown copyright*]

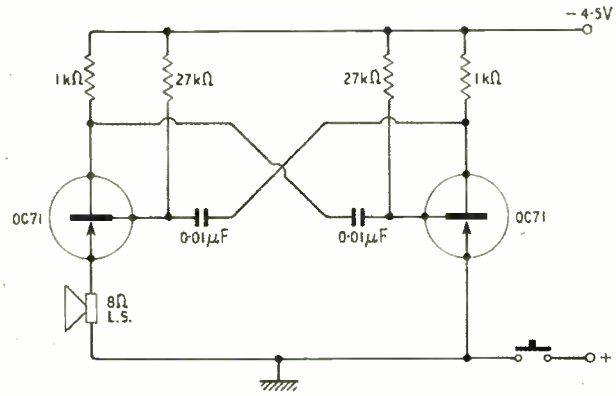



*Fig. 4.—Circuit of the experimental multivibrator of Fig. 2. The loudspeaker is included for demonstration purposes*

elements. It is likely that they will find application in the construction of active devices of the metal interface type and in the field of super-conducting cryotron elements. In the meantime, as knowledge of these techniques applied to the production of thin film electronic components increases, electrical properties will be assessed for an increasing number of environmental and operating conditions and a wider range of materials will come under investigation.

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# Voice recognition

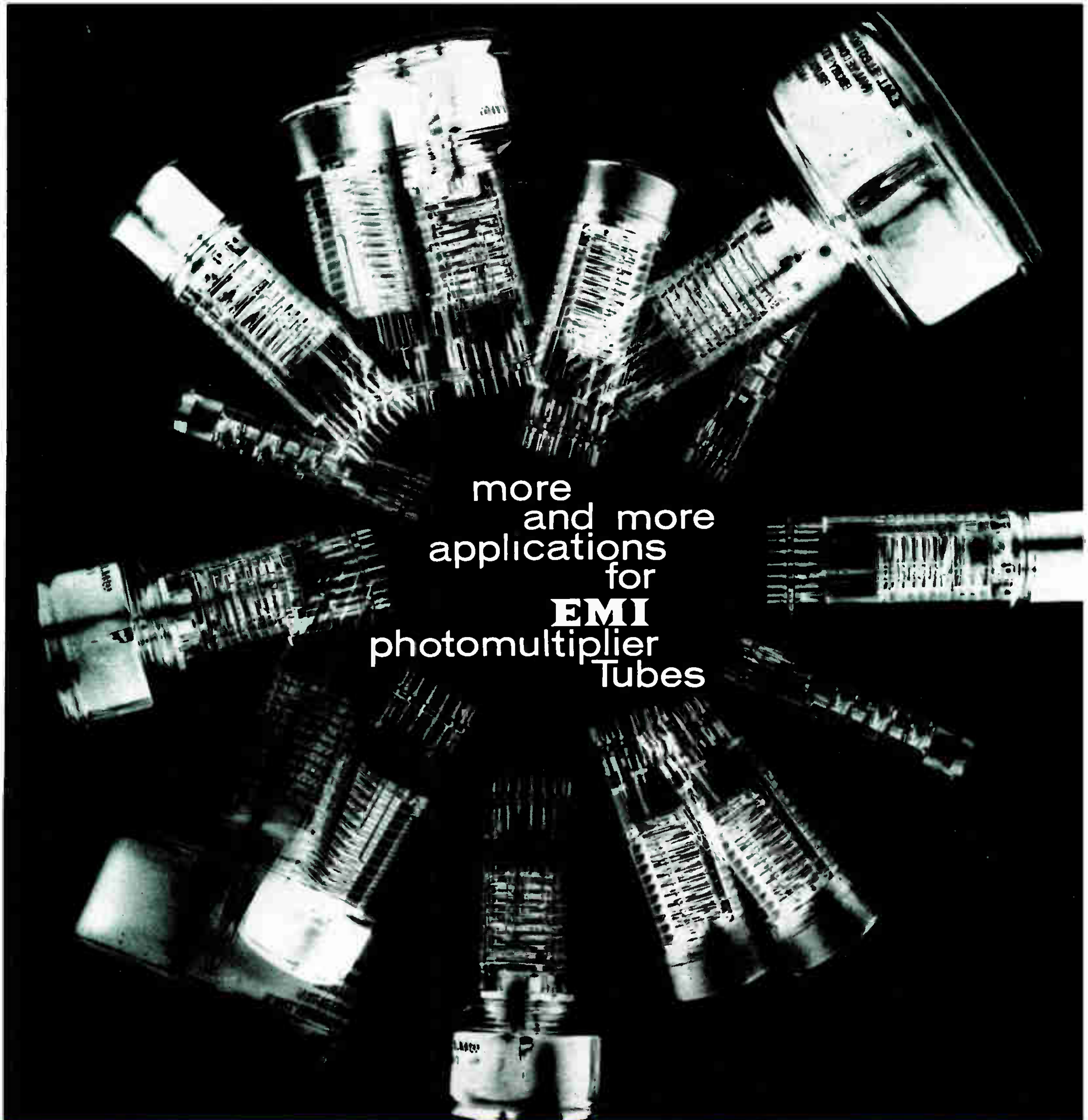
I.B.M. recently demonstrated an experimental machine which will recognize and obey spoken commands. It was attached to a desk adding machine, modified for operation by relays instead of the usual push buttons. The machine was built to recognize only the numerals 0–9 and the words plus, minus and total. Numbers could be dictated with the necessary instructions and the adding machine performed the calculations just as if the buttons had been pressed.

The apparatus actually distinguishes two consonant sounds only, the explosive consonants like s, t and the soft sounds like th, f. It can also distinguish between vowels like i and o. For the numerals, three characteristics suffice. Every numeral has an initial explosive consonant or a soft consonant or neither ; it has a middle recognizable vowel ; and it has a final sound which is again one of three possibilities. With three things each taken three ways there are 27 combinations and the machine has to respond only to 13.

It was stated that the consonant recognition is done by means of the different voice frequencies in consonants, but that the vowel recognition depended on the phase relations of the components of the waveform.

It is envisaged that a simple apparatus of this kind could, when further developed, find useful application, especially in stock-taking, since the user would have both hands free. It is, however, mainly a step in the much more difficult task of developing a system which will respond to a much wider range of speech. It may be a step towards one which will type out a letter dictated to it and, with a computer and speech synthesizer provide automatic translation from one language to another.


*The picture shows the demonstrator speaking into a microphone connected to the apparatus on the right which operates the adding machine in the middle*

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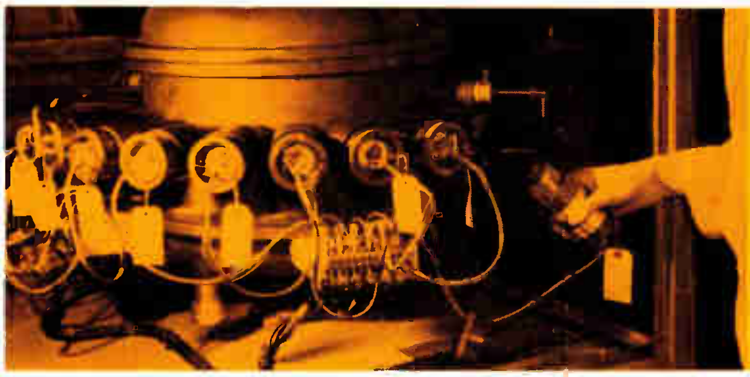
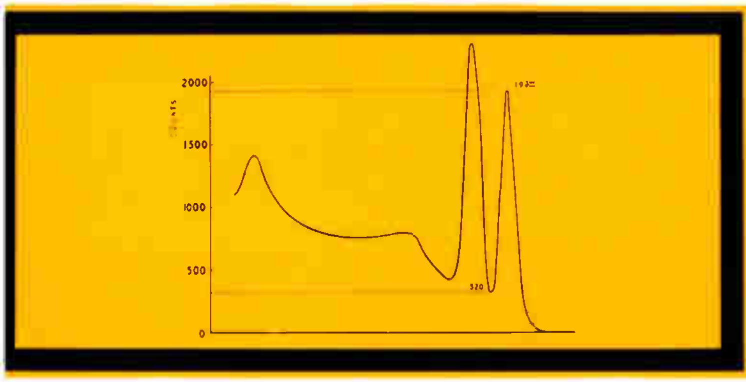
# EMI PHOTOMULTIPLIER TUBES

The EMI range of photomultipliers is one of the largest in the world. Tubes are available from 1″—12″, in a broad spectral response range from ultra-violet to infra-red, supplied with glass and quartz windows and with various types of photo-cathode for specific applications.



A view of the polychromator in the Hilger and Watts direct reading vacuum spectrograph which facilitates the rapid automatic analysis of carbon, phosphorus, sulphur, manganese, silicon and other elements in steel. EMI type 6256B Photomultiplier tubes were chosen for this application by virtue of their stability and excellent dark current characteristics.




A typical curve of energy resolution of $Co^{60}$, using a 3″×3″ thallium activated sodium iodide crystal coupled to an EMI type 9531 Photomultiplier tube. In order to obtain good resolutions the photomultiplier tube must have good photosensitivity, high collection efficiency of photoelectrons into the first dynode, and a uniform cathode. EMI tubes are noted for these qualities.

Spectrophotometers in the Perkin-Elmer range depend for their accuracy upon the quality of the incorporated photomultiplier tubes. These must be highly stable and have good photosensitivity and low dark currents. The characteristics of the EMI type 9529 are ideally suited to this application.

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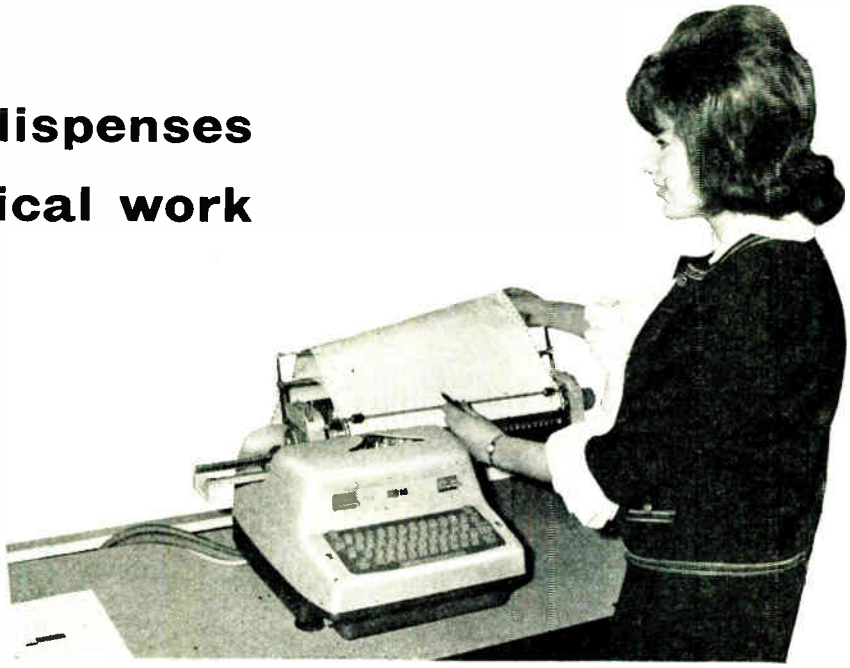
# This DAMSEL dispenses with clerical work



IT is generally agreed that any device to reduce production-line clerical work, without loss of information, must result in greater efficiency—DAMSEL is such a device. The initials stand for Data Automatically Monitored, Selected and Electrically Logged—a system developed by the Digital Engineering Co. Ltd.

Damsel provides a speedy data transmission link, without recourse to written records, between individual machines in the production line and the control office. By simply glancing at the typed output of a remotely controlled electric typewriter, the production supervisor gets an immediate overall picture of the operation of up to 60 machines in the production line. This is presented in the form of a printed record of the idle and running time of each machine, duration of and reasons for stoppages of individual machines, and the time taken by the maintenance engineer to reach the point of the breakdown and to clear the fault.

A 20-in. long carriage on the typewriter enables the output from up to 60 machines to be recorded, but it is considered possible to accommodate up to 150 machines in a single electric typewriter with a 30-in. carriage.

In addition to the output writer, the equipment comprises chiefly an idle/run sensing box for each machine and the main control station. Each idle/run box contains a sensing device, which automatically detects the condition of the machine, and is fitted with an operator-controlled idle time fault coding device.

The main control station contains a scanning and readout control circuit and a printout control circuit. The scanning and readout operation is initiated by a built-in clock and the frequency of scan can be pre-set in 12 steps between 1 and 60 times per hour.

Indication that the machines are running can be given by either a colon in the appropriate column or vertical strokes which join to give a continuous line.

Interrogation pulses from the scanning control are sent to each machine sensing unit in a pre-selected sequence, and the machine transmits a pulse back to the control station indicating the condition of the machine.

If a fault occurs, the machine is stopped and this is recorded in the appropriate column on the electric typewriter as a series of zeros. Once the fault is cleared, the operator records the type of fault, before starting the machine, by recording the pre-arranged fault number on the fault coding device.

The fault-coding switch can also be used as a means of calling assistance. As soon as a machine stops and the operator knows what assistance he requires, he operates the switch and the next printout carries in the column for that machine a code number indicating the type of assistance required. If a maintenance engineer has to be called, the time of his arrival and of his departure can, if desired, be indicated on the printed record.

Information can also be recorded on punched-paper tape or cards for subsequent analysis.

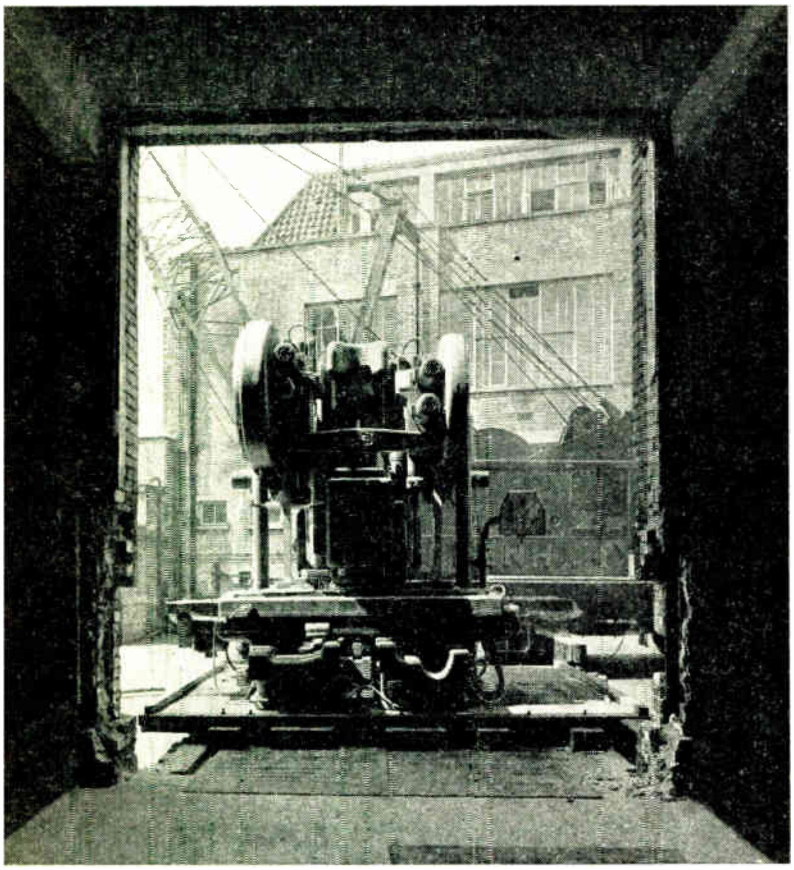
**For further information circle 38 on Service Card**

## Pictures in the dark

With the development of two 1-in diameter television camera picture tubes by E.M.I. Electronics Ltd., which are sensitive to the infra-red and ultra-violet parts of the spectrum, respectively, it is now possible to take television pictures in visible light. A scene that is illuminated by infra-red light cannot be seen directly by human beings but it can be 'seen' and pictured by a television camera and presented for normal viewing on a television receiver screen.

This means that industrial closed-circuit television systems can now be used to 'see in the dark'. Another application for a television camera fitted with an infra-red-sensitive picture tube is the remote and accurate measurement of the temperature of heated piece parts and materials. All heated materials radiate infra-red energy and the amount of radiation is a measure of the temperature of that material. Therefore in, say, a furnace process, the material being heated can be 'looked at' by a TV camera with an infra-red tube and the output from the camera can be presented on a meter dial which is calibrated in temperature.

**For further information circle 39 on Service Card**



# Sperry install an automatic jig borer

**This report gives details of a new automatic multi-purpose machine which has been installed by Sperry Gyroscope. It describes some of the functions of this 54-tool machine, which include jig-boring, milling, drilling, reaming and tapping, and one specific job which is now being produced in one-fifteenth of the time originally taken.**

AN AUTOMATIC jig-boring machine of French design, the only one of its type in Britain, has been installed by Sperry Gyroscope and is now fully operational. This is the 'G.S.P.-Matic' a 3-co-ordinate numerically-controlled dual spindle head machine for automatic machining cycles including jig-boring, boring, milling, drilling, reaming and tapping with fully automatic changing of up to 54 tools.

The G.S.P.-Matic has been designed to bring the maximum extent of automation to prototype, small and medium batch production with the object of reducing floor-to-floor times for the machining of components to a minimum. With this machine, far-reaching time savings are achieved by the reduction of non-productive time through the centralization of a large number of different machining operations, automatic programme control and, when required, the automatic changing of tools.

### Application and Accuracy

Sperry have installed this machine to help to produce magnetic storage drum mantles. These are large metal drums in which 434 head-mounting holes are required. The specification calls for the hole axes to pass through the centre of the mantle to within 0·0003 in.; the operations involved are drilling, boring, broaching and tapping for each hole. The complete sequence of operations is now being accomplished in one-fifteenth of the time originally taken! In the words of one of the management of Sperry: 'This G.S.P-Matic is the most spectacular and it is obviously going to be the most profitable automatic machine we have installed.' The manufacturers of the machine state that it has a positioning accuracy in the $x$, $y$ and $z$ axes of 0·0002 in. at an ambient temperature of 20 °C ± 1 °C and Sperry say that with a machine of this accuracy the proof of absolute accuracy is very difficult but they, and others, have made checks and are pretty certain that the claims made for the machine are true.

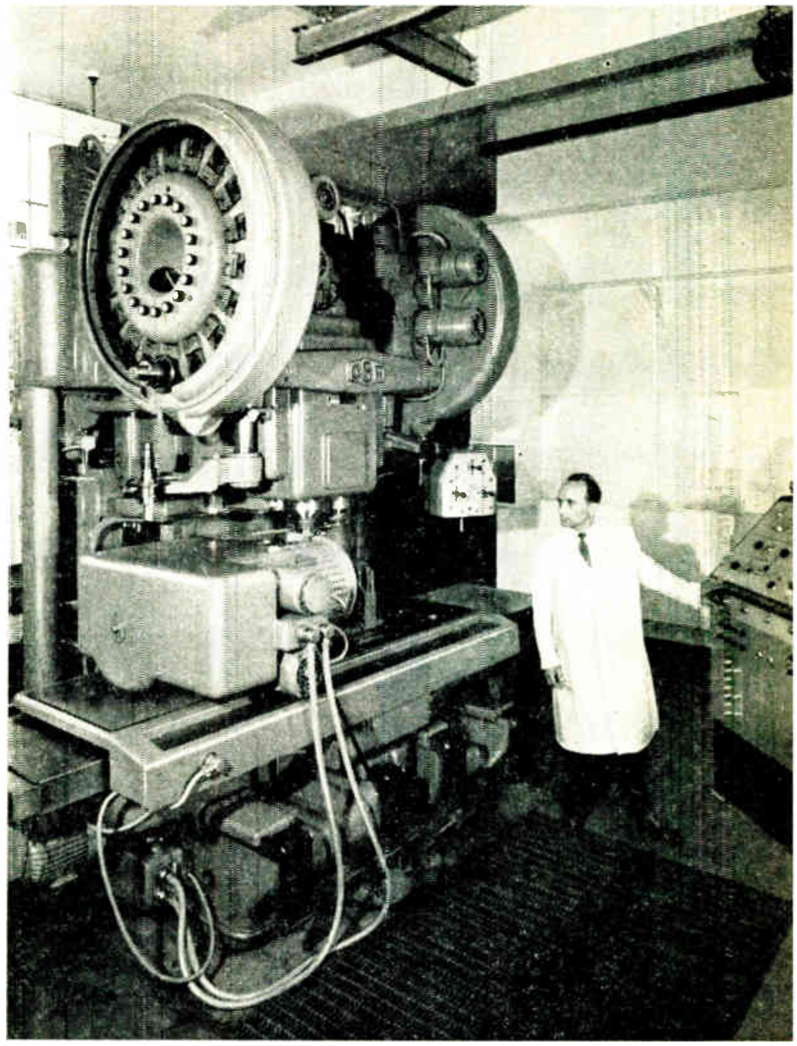
Control of the machine is effected by a 35-mm film in which coded holes are punched to provide instruction signals. These are amplified and used to operate the appropriate relay to actuate worktable movement, tool action or a tool change according to the pre-determined sequence punched into the film.

The operation of the machine can be automatic for all functions but it can also be remotely operated manually from the control console. Alternatively, it is possible to combine the automatic and manual operation in that one is able to override and supplement machining instructions punched into the film from the console.

A rotary table or dividing head (power operated) can be fitted to the machine. Their control is either by the punched film or by manual pre-selection, according to that being utilized for other machine functions.

### Preparation of the Control Programme

The control programme or sequence of operations is prepared from the drawing of the piece-part to be machined. An arbitrary zero is selected off the drawing and the position of all the machining operations is measured, with respect to the zero, as $x$, $y$ and $z$ co-ordinates and listed on a card. The $x$ co-ordinate represents necessary sideways movement of the worktable, the $y$ co-ordinate the forward or backward movement and $z$ the movement of the tool. Having produced the table of $x$, $y$ and $z$ co-ordinates for the work piece, these are grouped together in a logical order so that all operations of the same kind are done together, e.g., all ¼-in. diameter holes would be drilled one after each other before changing the tool. Also additional information about machine feed rates, etc., is inserted in the programme. The $x$, $y$ and, if necessary, $z$ co-ordinates, and the machine instructions are then punched out on the keyboard of a machine somewhat like a large typewriter which produces the punched film. Perforations in 10 parallel lines (corresponding to the numbers 0 to 9 inclusive) are punched in rows of five, each now representing the 5-digit code used to define the data. The film is now ready and can be fed into the scanner in the control console. This necessarily simplified description of the control programme indicates that this could be carried out by a jig and tool draftsman.



*This shows the complete machine with an operator alongside the control console*

### Control System

The scanner or readout device in the control console converts the coded holes into corresponding signals photoelectrically. Ten in-line photoelectric cells are used to read off the punched-hole coding and the resultant output is amplified by transistors and fed to the relays controlling the machine function.

Three separate but similar control systems are fitted to

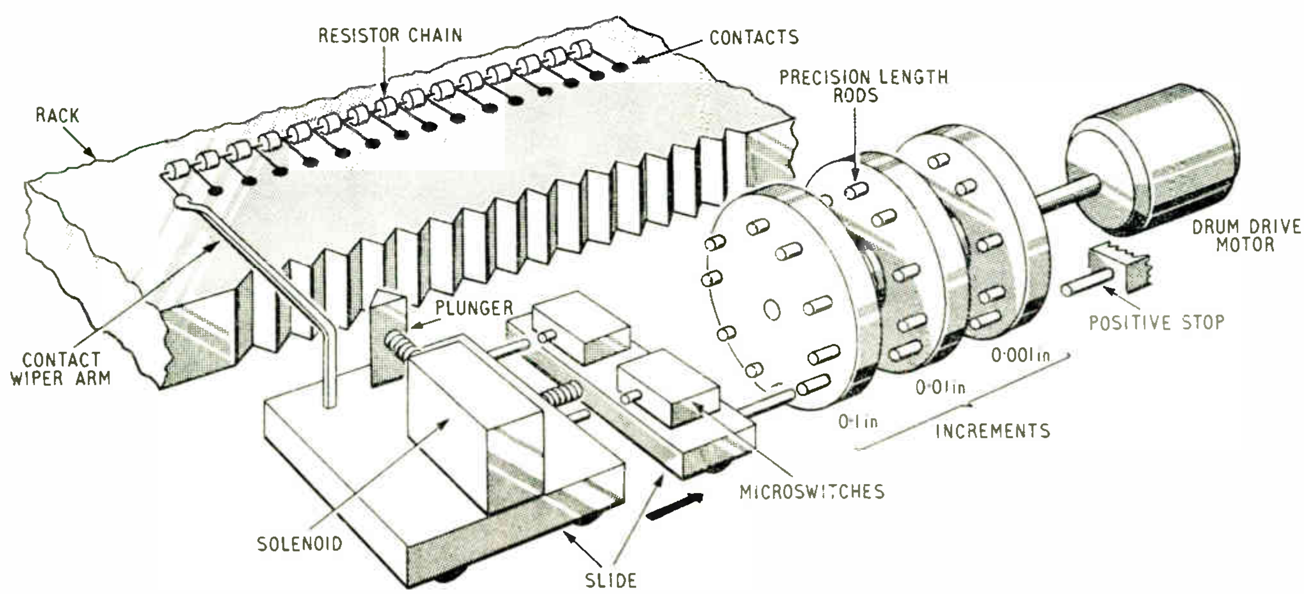
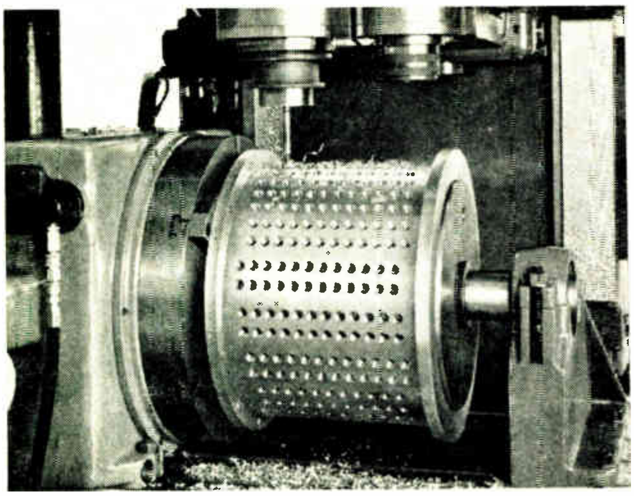
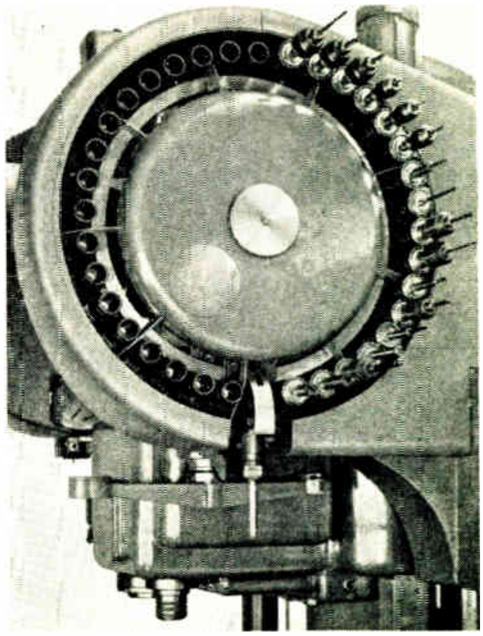
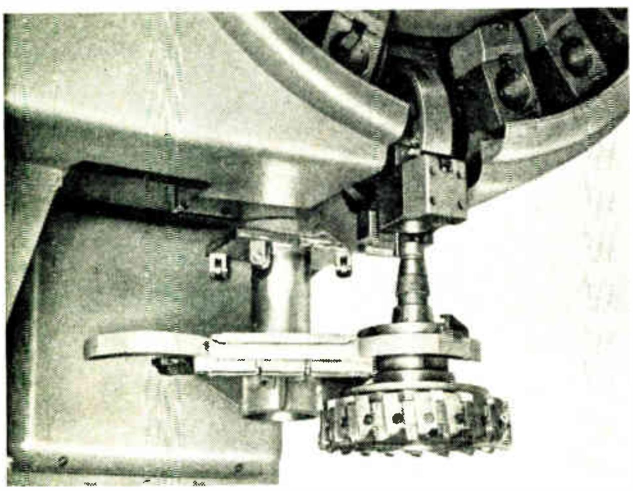



*Fig. 1.—This artist's impression of the major components of the control system indicates the principle of operation*







*Above: Shown here is one of the tool magazines. This one is associated with the light spindle and contains up to 36 high-speed tools. Another magazine of similar size, on the other side of the machine, accommodates up to 18 heavy-duty tools*

*Above Left: A close-up of the Sperry drum mantle in which 434 holes are automatically drilled, bored, broached and tapped by the G.S.P.-Matic*

*Left: Illustrated here is a heavy-duty face-milling cutter during the automatic tool change operation*

the machine for vertical, longitudinal, and transversal positioning; the basic system used in each case is the electronic control of electrical and mechanical elements.

Mounted on each moving component of the machine is a bar in the form of a rack with 0·5 in.-pitch teeth along its face. In line with the form between each tooth is an electric contact and when the rack is moving these contacts sweep over a brush. All the contacts along the rack are connected in series with a resistor between each contact, and the chain of resistors forms one arm of a Wheatstone bridge for coarse positioning. The brush over which the contacts glide is anchored to a small slide that is mounted on rollers allowing movement with minimum of resistance in the same plane as the moving rack. This slide forms part of the actual positioning device and is contained in a box mounted in a fixed position on the stationary part of the machine.

Fig. 1 shows in a simple diagrammatic way the component parts of the positioning system. Accurate positioning is obtained by using four separate but similar electrical circuits which rely on the movement of the machine components to change the resistance in one arm of a Wheatstone bridge. The selection of a dimension to the nearest 0·5 in. is achieved by unbalancing a Wheatstone bridge by a known amount. This means that one arm of the bridge is set to a resistance value that is equivalent to the resistance presented to the bridge by the required contact on the rack. It is done automatically by the punched film or it can be done manually with controls on the control unit. The unbalance results in a current which operates an a.c. drive motor for the moving part of the machine. The direction of travel of the moving part of the machine and the rack is determined by a system of polarization controlling the direction of rotation of the drive motor. This enables the rack to travel directly to the determined position from either direction without having first to return to its theoretical zero. When the rack is in motion the contacts associated with it sweep over a brush until a position is reached where the resistance presented by the particular contact touching the brush is such that the bridge is balanced. At this point the drive motor is switched off and simultaneously a plunger, on the small slide which carries the contact brush, is released and positively engages the form between two of the teeth on the rack. Therefore, the rack is locked to the roller-mounted slide which not only carries the plunger and contact brush but also a separate spring-loaded section and two precision microswitches.

After this stage, the direction of movement for final positioning is always the same, no matter from which direction the rapid approach has been made. This is determined by the engagement of the plunger which also switches on the current to a d.c. motor which drives the moving part during the final positioning stage. In the final positioning the moving part carries the small slide along with it until an adjustable stop causes initial contact to be made between a pad on this slide and a microswitch on the separate spring-loaded section of the slide. Operation of this first microswitch causes the current to the drive motor to be reduced and, therefore, the speed of the motor to be reduced. Movement of the slide base continues until the spring loading of the separate section is further compressed and a second microswitch on the separate section of the slide makes contact with a second pad and switches-off the drive motor. The adjustable end stop is in fact an end stop and three precision-length rods.

Setting the movement at increments of less than 0·5 in. is achieved by interposing three of a series of precision-length rods between the slide base and the positive stop. These length-rods are carried in three small drums, rotating on the same axis, parallel to the direction of movement. The rods are disposed radially in the drums, 10 to a drum, and can be indexed so that they are in line with the positive stop.

Number one drum serves two purposes. The first five length-rods are used to give the 0 to 0·4-in. settings, breaking down the 0·5-in. spacing between the teeth on the rack into 0·1-in. increments. The second half of the drum is used for a similar purpose, but rods are 0·0005-in. longer than the corresponding rods in the first half.

The number two drum carries rods to give settings from 0 to 0·09 in., in increments of 0·01 in.

The number three drum carries rods to give 0 to 0·009-in. settings, in increments of 0·001 in.

The radial position of each drum and, therefore, the allowable movement of the table or moving part is once again set by the automatic or manual control unit. In each case, the electrical system for setting the drum is similar to that used for the 0·5-in. increments. Around the perimeter of each drum is a series of contacts each connected by a resistor to its neighbour. The chain of resistors in each case forms one arm of a Wheatstone bridge, making a total of three bridges for the drums. The setting of the required dimension or movement unbalances the bridge and the appropriate drum is driven until balance is restored first in the 0·1-in. increment bridge, secondly, in the 0·01-in. increment bridge, thirdly, in the 0·001-in. bridge. In this way the appropriate length-rods are positioned in line with the end stop.

### Security and Maintenance

A safety system is incorporated in the G.S.P.-Matic by means of the interlocking of all machine controls, to ensure a signalled position has been achieved and the machine cannot operate further unless every positioning movement, function, correct tool change, etc., transmitted by the punched film signals has been correctly achieved.

All relays are grouped in self-contained, plug-in type sub-units and can be instantly withdrawn and replaced. All relays are telephone type of proved reliability.

A system of interlock relays and fuses automatically prevents machining operations being continued to incorrect dimensions and all electrical equipment concerned with any particular machine function is grouped together and indicated in relation to this function, thus enabling immediate identification of any suspect unit.

**For further information circle 40 on Service Card**

# High Stability Resistors

Morganite Resistors Ltd., a member of The Morgan Crucible Group, has recently announced the results of some tests which have been carried out on high-stability resistors after storage for up to ten years. The resistors, Megistors, were developed in 1950 and went into full-scale production in 1952. In values up to $10^{13}$ Ω, the resistors are used in apparatus for the accurate measurement of ionizing radiation, the currents being of the order of $10^{-10}$ A.

Early Megistors were individually measured for resistance and for temperature and voltage coefficients and the records have been retained. A recent check has been made on several hundred resistors manufactured between 1952 and 1955 and taken at random from stock. The resistors were of value $10^9$ and $10^{10}$ Ω. It was found that no resistor had changed in value by more than ±10% and that the average change of 100 resistors of $10^9$ Ω after 10 years was −3·26%. Most resistors showed a negative change.

Resistors of $10^{10}$ Ω manufactured in 1955 were tested for temperature coefficient and showed an average change of +0·014%/°C and maximum changes of −0·2%/°C and +0·17%/°C. Thirteen resistors showed no change. Changes of the voltage coefficient were still smaller with an average of +0·0011%/V and maximum changes of −0·05%/V and +0·04%/V, twenty-four resistors showing no change.

More recently manufactured resistors were checked monthly for a year and were found not to vary by more than ±1% in resistance value. In all cases the greater part of the variation took place within the first three months. During this period the curves show irregular variations about a mean drift towards a lower value. After three months these irregularities become much smaller and the rate of drift is also reduced. The values used in these tests varied from $10^9$ Ω to 3 × $10^{12}$ Ω.

Current Morganite resistors are made in standard tolerances of ±5%, ±2% and ±1%.

**For further information circle 41 on Service Card**

## ★ FOR THE BUYER

You must have read about a number of products and processes in this issue of which you would like further details. You can obtain this information very easily by filling in and posting one or more of the enquiry cards to be found inset in the front and back of the journal.

**In this article some aspects of the erosion of copper soldering-iron bits are considered and discussed. The aim has been to establish the causes of the bit wear and to survey the accepted methods of reducing this loss.**

# Erosion of soldering-iron bits

***By P. SHARPLES***

SOLDERED joints play a large part in communications technology and in the electronic industry generally. It is therefore readily understood that considerable attention must be devoted to all aspects of soldering so that the process can be carried out in the most economic fashion.

It is well known that in production soldering, the soldering-iron bits are worn away rapidly and it has been widely presumed that this wear is mainly due to three factors, viz.:—

Oxidation of the copper due to heat.
Attack of the flux on the copper bit, and
Absorption of the copper into the tin of the solder.

As the flux was initially thought to be largely responsible for the frequent need to resurface copper bits, it is perhaps useful at this stage to survey the types of fluxes, classed as non-corrosive, which are commonly employed in soldering.

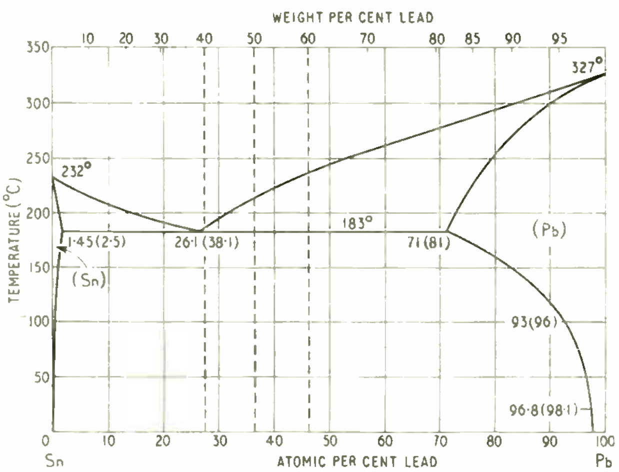



*Fig. 1.—Equilibrium diagram of solder alloys. The dotted lines indicate the usual compositions*

Essentially these are either based on pure rosin, or rosin containing a certain amount of organic activating agents. Examples of these activating compounds are:—Aniline hydrochloride, glutamic and glycolic acids, ammonium lactate, and materials of the amine addition type. The higher the activity of the additive, the more inherently corrosive will the flux be and it is this consideration which limits the range of activators that can safely be used for fluxes for electronic and similar applications.

Ersin Multicore Solders, containing five such threads of activated flux, were used throughout the present experiments.

The degree to which the third factor—that of copper absorption by the tin—affects the bit, will obviously be dependent on the actual composition of the solder. The alloys most frequently used for normal purposes are those having the compositions indicated by the dotted lines on the equilibrium diagram of Fig. 1.

In an effort to minimize bit erosion, three techniques have been widely employed, viz.:—

The use of a less easily eroded alloy, such as copper-chromium.
To electroplate the bit with some harder material, commonly iron.
To use a copper-loaded solder alloy.

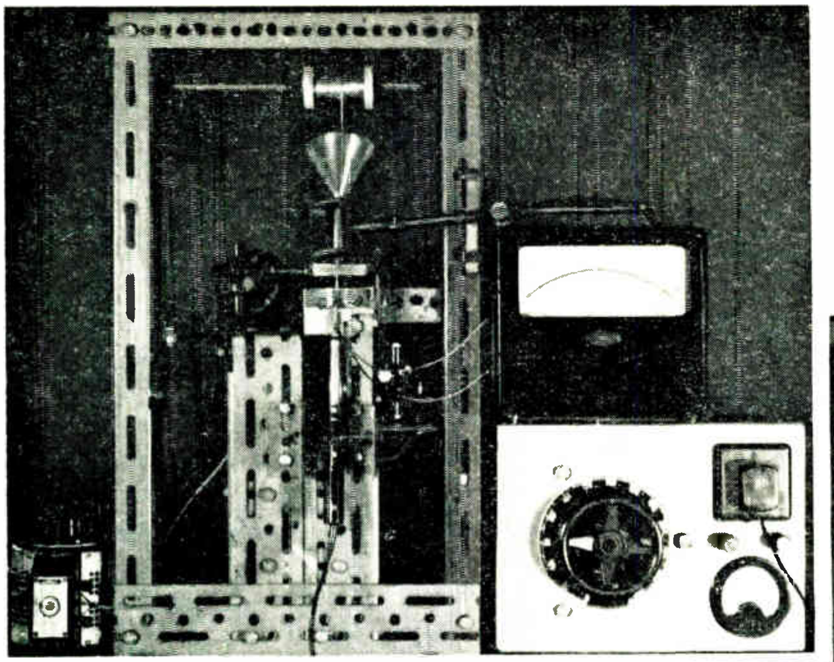
The previous considerations suggested that the present experiments should be directed first towards determining the relative importance of the various sources of bit wear, and secondly, towards assessing the value of the individual methods of combating this loss.

### Work by Previous Investigators

Little recorded work appears to have been done along the present lines. However, reference is made to the work of H. Künzler and H. Bohren ('Untersuchungen an Feinlötstellen'), who conducted a more general survey of the techniques involved in the production of high-quality soldered joints.

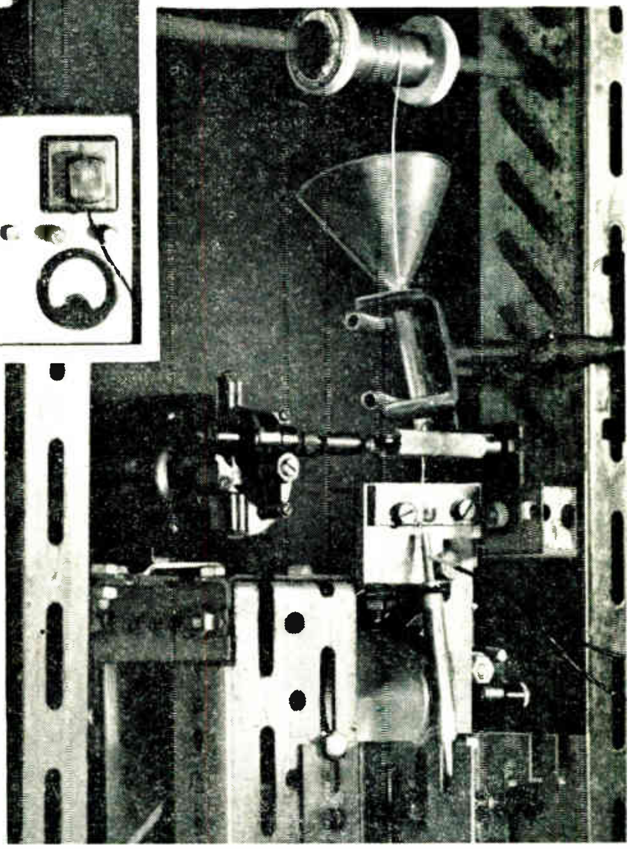
Their survey was based on the following questions, which are of paramount importance in soldering practice:

(1) Can the soldering time be shortened by making active



*Left: Fig. 2.—General view of the test apparatus*

*Below: Fig. 3.—In this close-up the soldering iron under test can be seen and the feed arrangements for the solder*



additions to the pure rosin without fear of causing corrosive attack to the joint or neighbouring metal parts?

(2) Which is the most favourable soldering temperature?

(3) How can the copper loss (i.e., the wearing away of the soldering iron head) be reduced?

The section of their work which dealt with question (3) had only a relative importance since the experimental conditions did not correspond to those of soldering proper. However, the relevant ideas were clearly shown. They demonstrated in a qualitative fashion that a solder which originally contains 1–2% copper and is in effect already saturated, will not cause a soldering-iron bit to wear away so rapidly as would a copper-free solder. This is the basic principle behind all copper-loaded alloys which are designed to minimize bit erosion.

Ersin Multicore Savbit Solder is such an alloy and was the subject of some of the tests in the present investigation.

**Details of Apparatus**

It was decided that as far as possible conditions comparable to those encountered in soldering practice should be simulated in the tests that were to be carried out. The writer did not think it of great value merely to immerse the copper bits in baths of molten solder and observe the copper loss in this manner, since many of the features involved in the production of a soldered joint would not be reproduced. For example, as the solder bath is essentially of limited capacity, an exponential saturation of the liquid solder by copper would undoubtedly be observed. These conditions, which would result in a tendency for the rate of copper loss to decrease with time, are not representative of soldering practice, where a fresh supply of solder is used for each joint to be made. Further, the arrangement makes no allowance for the pressure and 'wiping action' which are invariably present between the bit and the component undergoing soldering.

In view of these and other considerations, the equipment shown in Figs. 2 and 3 was constructed. Fig. 4 makes clear the essential working features of the arrangement.

The pivoted soldering iron, of 25-W capacity, is actuated by a camwheel and moves on and off a continuous feed of solder wire. A pair of milled rollers—one motor-driven, the other idling—serves to maintain a constant solder feed rate. The roller and camwheel speeds are both adjustable to some extent by means of Variacs connected in the circuits of the respective motors. A thermocouple in conjunction with a millivolt-meter enables the temperature of the bit to be measured continuously. The inset in Fig. 4 shows the manner in which the thermocouple junction is secured in the bit. During an actual run, the molten solder flows to the base of the bit where it collects in a pool which grows until it is large enough to form a drop. These drops fall periodically and adhere to the aluminium camwheel until they are removed by the scraper and fall into the receptacle below.

**Experimental Procedure**

The cam profile and motor speed were such that a soldering contact time of approximately 1 second was achieved, a figure which might well be encountered in actual soldering practice. The recovery time between 'joints', each of which consumed approximately $\frac{1}{4}$ in. of solder, was about 3 seconds. This was found to be a sufficiently long period of

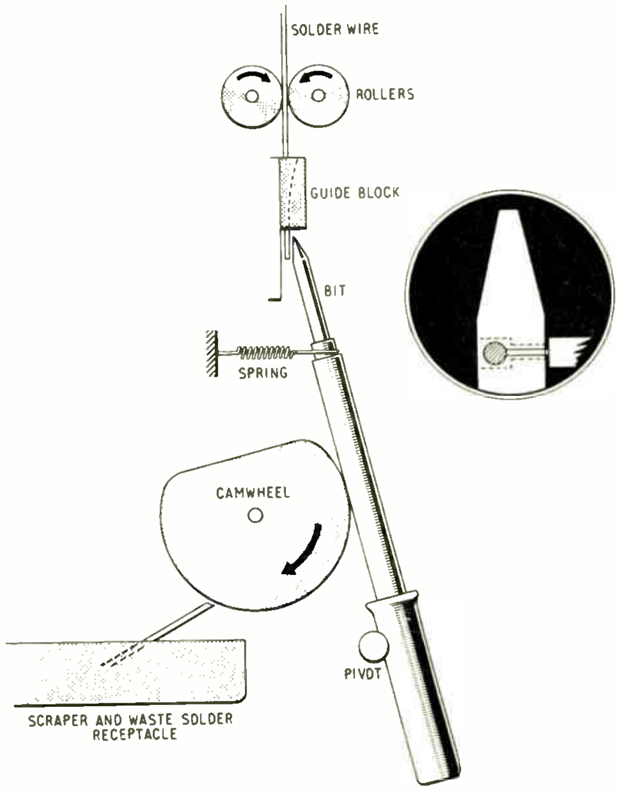



*Fig. 4.—Details of the test apparatus. Inset is shown how the thermocouple was fitted to the bit for temperature measurement*

time for the soldering iron to maintain an equilibrium temperature considerably in excess of that for the liquidus of the solder.

The variables of the system were: solder composition, bit material, soldering temperature and duration of run; i.e., number of 'joints'. *Note.*—Hereafter the inverted commas will be omitted and the word joint can subsequently be taken to mean the result of melting a length of solder wire comparable to the amount consumed in the production of an actual soldered joint.

It was initially intended to study the effect of soldering temperature, as one of the variables, on the rate of bit erosion. In fact, the temperature could not be substantially lowered as it necessarily had to be maintained somewhat in excess of the solder liquidus temperature. Further, the upper limit was set by the rating of the soldering iron and any increase in current above this value would seriously have shortened the life of the heating element. It was thus not possible to vary the soldering temperature at will.

A series of runs were made for a range of values of each of the other three variables. After each run the flux residue was removed from the bit with trichloroethylene and the solder was dissolved away by boiling in 50% hydrochloric acid. Direct weighing gave the copper loss. The extent of the erosion in each case is illustrated by the photographs of Fig. 5. Some bits were sectioned laterally at the tip and examined end on under the microscope. Various photomicrographs were taken (Fig. 6) in order to determine the nature of the erosion.

A blank run was completed in which all conditions were exactly as for previous runs except that no solder was employed. This indicated the extent of the bit wear due to oxidation alone.

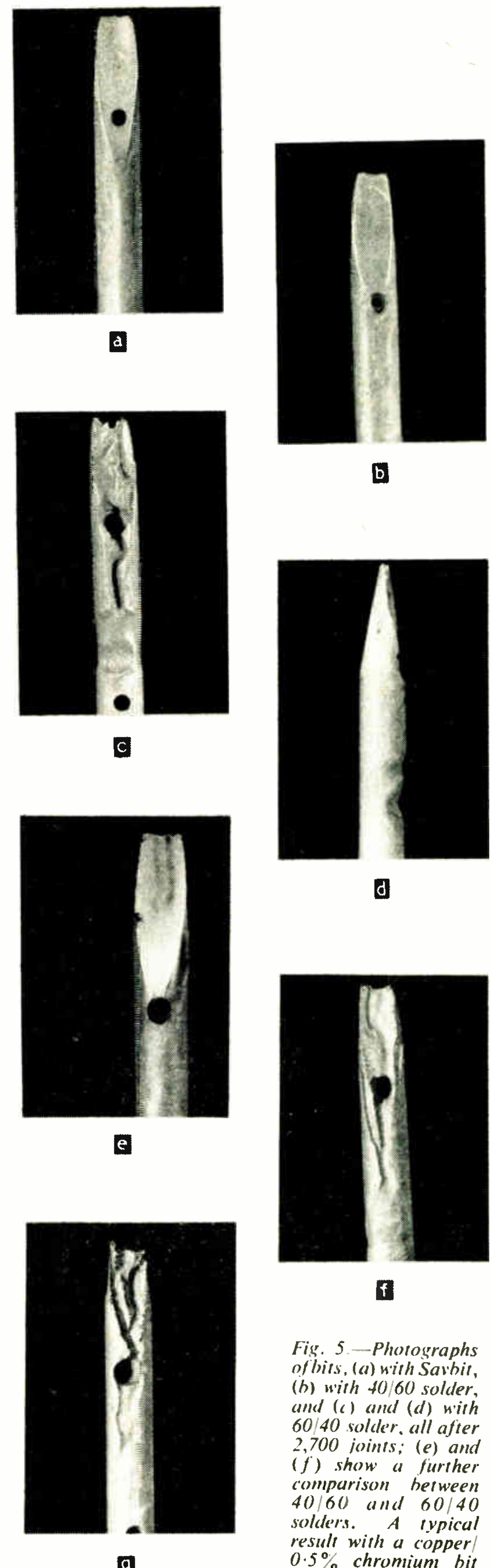



*Fig. 5.—Photographs of bits, (a) with Savbit, (b) with 40/60 solder, and (c) and (d) with 60/40 solder, all after 2,700 joints; (e) and (f) show a further comparison between 40/60 and 60/40 solders. A typical result with a copper/0·5% chromium bit is shown at (g)*

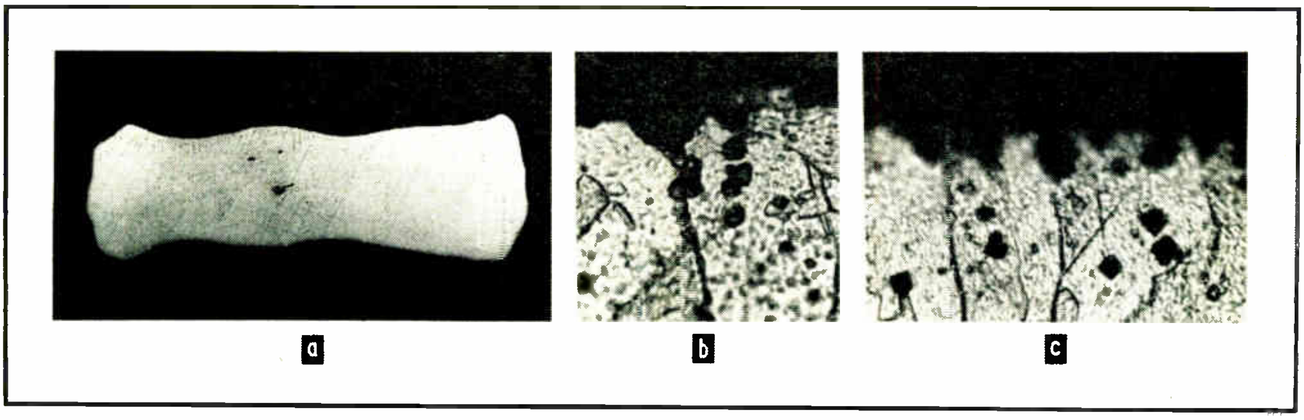



*Fig. 6.—Laterally-sectioned bit (a) photographed with a magnification of 16 times, 1,500 joints with 40/60 solder. At higher magnification, after etching, (b) and (c) grain boundary attack is evident*

Finally, an unused bit was boiled in 50 per cent hydrochloric acid and weighings were made in order to verify that the copper loss in the acid was negligible.

**Results**

The bits shown in Fig. 5 (a)–(c) have each been used to make 2,700 joints with Savbit (1·5 Cu/50 Sn/48·5 Pb), 40/60 (the tin content is always stated first) and 60/40 solders respectively. It can be seen that the bit used with Savbit solder is virtually in its original condition, while that used with the 40/60 alloy shows the initial stages of erosion along its length. The hole which accommodates the thermocouple has become enlarged. The bit in Fig. 5 (c) exhibits catastrophic erosion. The face is deeply channelled and a cavity has formed at a point corresponding to the junction between the bit and the soldering-iron body. The depth of this cavity can be appreciated from the side profile shown in Fig. 5 (d). Fig. 5 (e) and (f) again make clear the marked difference in the severity of the erosion incurred when using 40/60 (e) and 60/40 (f) solders.

A typical result of the experiments with copper/0·5% chromium bits is seen in Fig. 5 (g). This bit has been used to make 1,500 joints and the erosion suffered is apparently no less severe than that experienced with the copper bits, a result which was confirmed quantitatively—see Table 1. Fig. 6 (a) is a photograph of a laterally-sectioned bit at a magnification of ×16 and shows how the rectangular profile has been lost after making 1,500 joints with a 40/60 solder. At a higher magnification, after etching, grain boundary attack is seen to be very prominent [Fig. 6 (b) and (c)].

The details of the individual runs are given in Table 1, and the results are expressed graphically in Fig. 7. To facilitate comparison the curves are plotted on the same set of axes.

**Conclusions**

The results show clearly and unambiguously that the principal cause of soldering-iron bit erosion is that of solution of the copper in the tin of the solder alloy. The magni-

TABLE 1

| Test Conditions | Number of Joints | Average Bit Temperature (°C) | Weight of Bit Before (gm) | Weight of Bit After (gm) | Copper Loss (gm) |
|---|---|---|---|---|---|
| Commercial grade copper bit with 40/60 copper-free solder | 450<br>900<br>1,500<br>2,700 | 264<br>271<br>272<br>264 | 5·3522<br>5·3577<br>5·4842<br>5·2548 | 5·2814<br>5·2359<br>5·3073<br>5·0414 | 0·0708<br>0·1218<br>0·1769<br>0·2134 |
| Commercial grade copper bit with 60/40 copper-free solder | 900<br>2,700 | 269<br>259 | 5·3709<br>5·3950 | 5·0358<br>4·8117 | 0·3351<br>0·5833 |
| Copper/0·5% chromium bit with 60/40 copper-free solder | 450<br>1,500 | 294<br>295 | 5·5556<br>5·5334 | 5·3836<br>5·0628 | 0·1720<br>0·4706 |
| Commercial grade copper bit with Savbit Alloy No. 1 solder (50Sn/48·5 Pb/1·5 CU) | 900<br>2,700 | 292<br>270 | 5·2431<br>5·3105 | 5·1912<br>5·2261 | 0·0519<br>0·0844 |
| Blank run. Copper/0·5% chromium bit with no solder | 3 hour run (2,700 joints) | 269 | 5·5766 | 5·5466 | 0·0300 |

Unused bit. Initial weight 5·5693 gm. Weight after boiling in 50% hydrochloric acid 5·5613 gm. Copper loss 0·0080 gm.

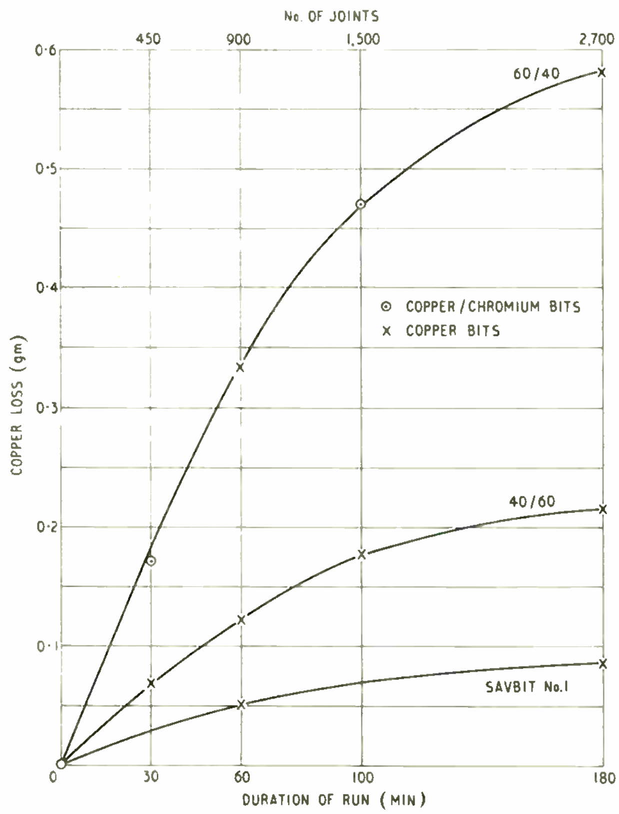



*Fig. 7.—Copper-loss versus number of joints. The curves are plotted from the figures of Table 1*

tude of the bit wear was found to increase rapidly with increasing tin content—see Fig. 7. The effects of all the other variables investigated in these experiments are of secondary importance only. The figures for the blank run showed conclusively that copper losses through oxidation are negligible.

The remaining factor—that of attack by the flux—can only be responsible for bit erosion to a very minor degree, since an identical flux was used in all the experiments, and the curves resulting from these experiments show that the controlling factor is the tin content of the solder. It must be made clear that the bit wear which results from flux attack can only be assumed to be negligible when one is considering fluxes of the non-corrosive type, such as are listed in the introduction. Investigations would undoubtedly reveal that more highly active fluxes would constitute a definite source of attack and it would therefore be misleading to generalize the statement to all types of fluxes.

The photographs of Fig. 6 show that the basic mechanism of the erosion is that of grain boundary attack. Only a very limited amount of metallography was done in the present work and it is therefore not possible to amplify this observation. It may well be that a more detailed investigation into this aspect of bit erosion would prove profitable.

It can be clearly seen from Fig. 7 that it is in no way beneficial to use a copper-chromium alloy for the bit material, since this erodes under soldering conditions at a rate almost identical to that for copper alone. Similarly, it was thought that to electroplate the bit with a harder material, say iron, although perhaps initially effective, would prove to be innocuous after a relatively short period of time.

Moreover, the resulting lower heat transfer would necessitate a higher heat input to the soldering iron. But, perhaps more important, an electroplated surface will not tin so readily as will pure copper. Electrodeposition is not then a satisfactory method of increasing the bit life.

In direct contrast, however, it was found that the use of a copper-loaded solder, such as Savbit No. 1 Alloy, greatly reduced bit wear under all conditions and as such provides very nearly the complete answer to the problem. By way of criticism, it was noticed during the course of the experiments that this alloy lacked the fluidity of the copper-free solders, but not, it was thought, to an extent sufficient to impair its soldering characteristics.

Apart from this minor disadvantage, the use of a copper-containing solder affords the only effective method of reducing the erosion of soldering-iron bits.

# Tape-recorded vibrations

AT the last I.E.A.* Exhibition Fairey Air Surveys demonstrated a new technique whereby up to four vibration generators can be controlled independently by a four-track magnetic tape recorder. In this demonstration a Ford Anglia was mounted on four vibration generators, one under each wheel, which were driven hydraulically and controlled by a four-track magnetic tape. Initially, signals are recorded on the magnetic tape which correspond to a pattern of vibration; in the case of a four-track machine, four separate sets of signals can be recorded and re-played. When re-played, the tape recorder produces electric signals which are used to control the amplitude of vibration of the generators. In this way it is possible to subject a motor car to a road and track vibration 'trial' without taking it outside the assembly shop.

* Instruments, Electronics and Automation.

**For further information circle 42 on Service Card**


*This illustrates one of the many applications of low frequency vibration generators which are driven by pre-recorded signals to simulate almost any required vibration condition*

# Remote monitoring system for industry

A REMOTE monitoring system, which can make measurements at unattended points several miles apart, and record or display those measurements or feed them into data reducing equipment at a central location, has been developed by E.M.I. Electronics.

Known as a Voice Frequency Telemetry System, because it transmits data along a telephone line on audible frequencies, this equipment will prove particularly useful to organizations handling the distribution of electricity, gas, oil or water, where it is necessary to control many units dispersed over long distances. For example, several unattended pumping stations along an oil pipeline can be remotely monitored from a central panel.

Another use for the system is in plants whose sites extend over large areas—for example, oil refineries, chemical plants and steel mills. A central panel can monitor the behaviour of the entire plant. If a two-way telemetry system is incorporated, the process being monitored can also be controlled at the central point.

Senders at the remote points can operate unattended for six months in temperatures between $-15$ °C and $+50$ °C. They can be connected to the central control point either by private lines or as normal subscribers on the G.P.O. telephone system. The latter method is often more convenient when transmitting data at comparatively infrequent intervals over long distances.

Transmissions can be made continuously, at specific times as programmed, or on demand. During continuous transmission, up to twelve variable quantities at each remote point can be sampled in sequence once every 16 seconds. If a higher sampling rate is required for any particular variable, that can be arranged.

When working to a programme, senders will report for a given period at predetermined times. For example, a transmission could start automatically every hour and last for five minutes. The sender would then switch itself off until the next hour.

Operation on demand is most suitable when using public telephone lines, or lines shared with other appliances. A call from the central receiving point will automatically switch on the unattended sender, which will introduce itself by a 15-second pre-recorded speech announcement of its name and number. Duration of the transmission is predetermined, but an override signal from the central receiver would cause the whole sequence to be repeated.

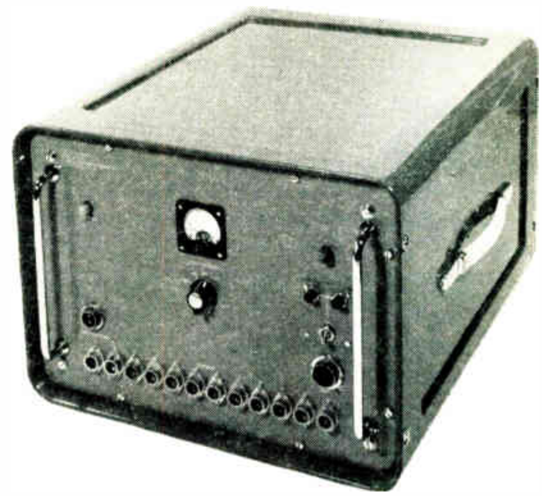
The Voice Frequency Telemetry System converts data into coded electrical signals which are transmitted along telephone lines between the point of measurement and the receiving equipment. This decodes the signals for recording, display or data reduction.

Measurements are converted into a variable voltage whose amplitude is proportional to the parameter being measured. Transducers are used for this purpose and a number of these are connected in turn into the transmitter by means of an electronic scanning switch. The output of the switch is connected to a modulator which produces a signal whose frequency is proportional to the input voltage level. This signal is transmitted to the receiver via the interconnecting line.

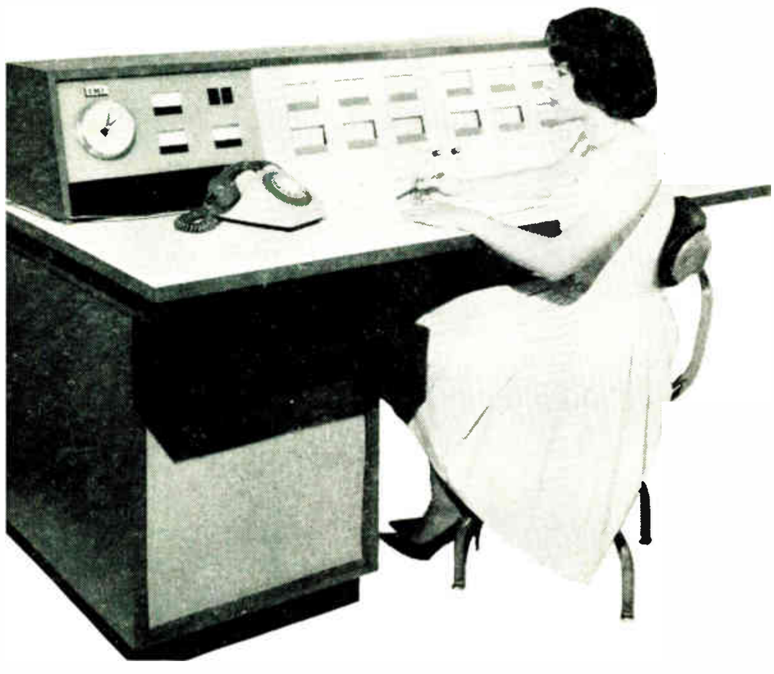
At the receiving station the process is reversed. The incoming frequencies are conveyed into a frequency sensitive discriminator which produces voltage outputs proportional to the original measurements. These potentials are applied to an electronic commutator driven in synchronism with the commutator in the transmitter, so quantities which were received in series along a line are switched into a number of parallel lines. Read-out devices such as indicating meters and pen recorders are connected to these lines.

An alarm system can be incorporated so that positive indication is given if any of these quantities rise above or fall below predetermined levels. Transducers producing a variable frequency output can be used instead of the voltage transducers.

**For further information circle 43 on Service Card**



*Above: Illustrated here is a typical voice frequency telemetry sender which is designed to provide facilities for monitoring twelve separate quantities at unattended out-stations, etc. It is transistorized and can if necessary be run from two 12-V batteries*



*Left: This shows the receiver console which is at the central control station. From this unit the various out-stations, etc., can be monitored and up to 12 quantities or parameters being measured can be displayed on the console panel*

# EQUIPMENT review

## 1. Low-Cost, Two-Line Intercom

CENTRUM ELECTRONICS have introduced a low-cost transistorized system to meet the demand for high-quality intercommunication in a small business, or where there is need for instant contact from a master station in one room to a sub-station in one or two others. Installation is extremely simple and takes literally only minutes; the thin connecting cable is just joined to colour-coded terminals and tacked in place between stations.

This Centrum T-3 system is unusual because the master station has been reduced to the same size as the sub-station. It is, in fact, only 7 in. × 3 in. × 5 in. yet the quality of voice reproduction and the styling remain as good as in the larger models in the range. The T-3 gives instant press-button contact; staff answer from anywhere in the room without moving from where they are or interrupting their own work. Their hands are free to handle papers and their answer comes back clearly.

The cost for the master and one sub-station is only £25 5s.; another sub-station can be added at any time for five guineas.

The T-3 is the fourth transistor system available from Centrum. The others are the T-5, T-6 (for six fully-intercommunicating masters) and T-10. Mains systems are the GB for up to 22 stations and Centrum Futura for as many as 1,000 extensions.—*Centrum Electronics Ltd., Terminal House, Grosvenor Gardens, London, S.W.1.*

**For further information circle 1 on Service Card**

## 2. Sealed Rotary Switches

DUBESCO HAVE RELEASED their Grayhill Series and Series 24 miniature rotary switches. These are robust sealed rotary switches which have been designed for use in professional equipment.

The contact resistance is 0·003 Ω initially and the life expectancy of the switch is 100,000 operations. Each set of contacts is rated at 1 A, 115 V a.c. with a resistive load or 0·25 A, 115 V a.c. with an inductive load. The switches can have up to 10 positions per bank and one or two poles per bank; up to 10 banks can be fitted to each switch. Variations on the standard switch are available.

Considerable environmental testing has been done on this switch including: 100 hr salt spray, 10–500 c/s vibration, 30 *g* shock, and humidity, sand and dust, fungus and explosion tests according to recognized U.S. specifications.—*Dubesco Laboratories Ltd., 5 Violet Hill, London, W.3.*

**For further information circle 2 on Service Card**

## 3. 19-in. Equipment Cabinets

PLESSEY have introduced a standard range of sheet metal cabinets for electronic equipment. Accommodating international standard 19-in. chassis, the cabinets are available from stock on short delivery.

Extreme simplicity of design, versatility and economy are the main features of the range. The basic unit comprises a top, four pillars and a plinth—the addition of stock side panels and doors completes the cabinet. This technique simplifies the racking of equipment, and additions to the basic unit are made as required from stock components.

A wide variety of 'optional extras' is available, including telescopic runner fitments, panel mountings, dust proofing and forced-air cooling. Although the standard finish is a silver-grey hammer tone, other finishes can be produced to order.

Because of the trend for electronic equipment to become increasingly compatible with office furniture, Plessey also offers a styling service which provides polished hardwood facia trimmings to customers' requirements.

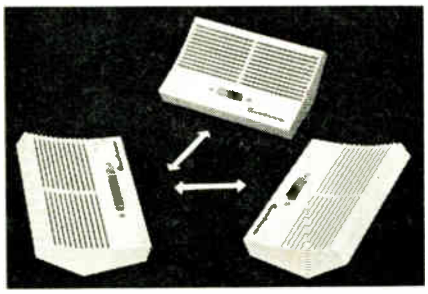
The Plessey international standard enclosures are available in heights of 3, 4, 5, 6, and 7 ft, 19-in. or 25-in. deep.—*The Plessey Co. Ltd., Sheet Metal Division, Cheney Manor, Swindon.*

**For further information circle 3 on Service Card**

## 4. Random/Sequential Access Buffer Storage

DI/AN CONTROLS, Inc., U.S.A., have added a random/sequential access buffer storage unit to their range of magnetic logic components and memory systems.

The buffer is available in two series, 100 and 300, each of which has models



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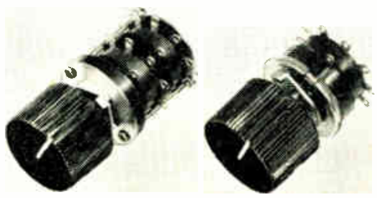

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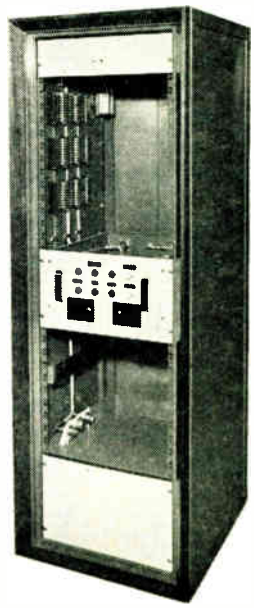

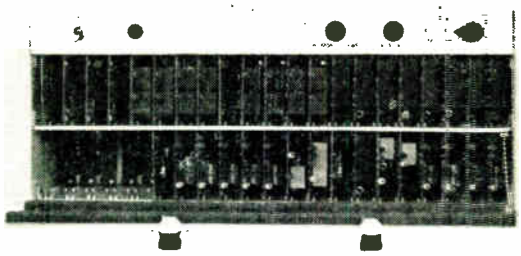

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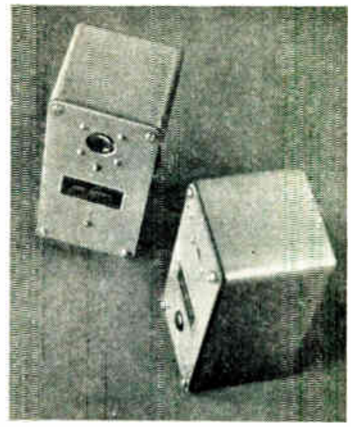

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with storage capacities of 256, 512, 1,024, 2,048 and 4,096 characters of up to 40 bits per character. The 100 series will read-restore or clear-write in 10 μsec and load or unload in 6 μsec. The 300 series performs these functions in 3·3 μsec and 2·5 μsec, respectively. The character access time is nominally 3 μsec for the 100 series and 1·5 μsec for the 300 series.

The buffer, designed for mounting in a standard 19-in. rack, is 7 in., 10½ in. or 14 in. high (depending on storage capacity) and 10 in. or 14 in. deep. It has a power drain of less than 300 VA depending on storage capacity. The power supply is provided as a separate unit for rack mounting or as an integral part of the buffer.

The main features of the buffer are three addressing methods, six operating modes, random interlacing of addressing methods and operating modes, high speed mode switching and a built-in test programme. The information in the memory can be regrouped in any format, stored words can be processed or shifted sequentially forward or backward or blocks of data can be shifted or inverted, all without destroying the original coherence of the stored information.—*Scientific Furnishings Ltd., Poynton, Cheshire.*

**For further information circle 4 on Service Card**

## 5. Industrial Photoswitch

A COMPLETE photoelectric switch which comprises only two units has been added to the range of photoelectric controls which are manufactured by Hird-Brown.

This PS11 Photoswitch provides the light projector in one steel box and the photocell and relay unit in another box; each unit measures 6 in. × 3 in. × 3 in. The light power output of the projector is such that operation of the photoswitch is guaranteed up to a distance of 10 ft. In operation an electronic circuit, working in conjunction with the photo-detector, amplifies the signal and operates a relay. The relay contacts are rated at 5 A, 240 V a.c. with a non-inductive load.

Both units are mains operated and together, making a self-contained photoelectric switch, they cost £18 15s. —*Hird-Brown Ltd., 244 Marsland Road, Sale, Cheshire.*

**For further information circle 5 on Service Card**

## 6. Laboratory Test Oven

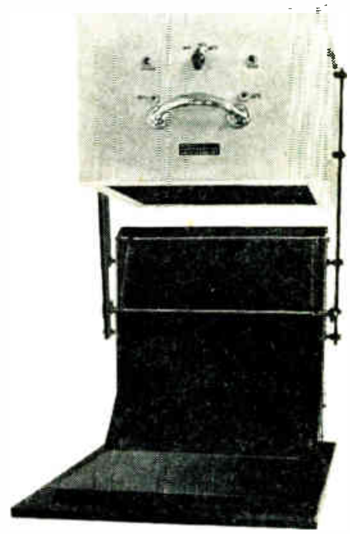
IN ORDER to speed up the work of testing experimental circuits containing semiconductors and such like objects, Contronics have developed an unusual oven which operates from room ambient to 100 °C.

The oven operates on the reverse principle to that of the deep freeze; that is, hot air is trapped in the inverted container of the oven. This has the advantage that the oven may be left in the raised or open position indefinitely but the temperature of the air in the oven will remain at that set on the control.

Basically the oven consists of a thermally-insulated metal box with an open base. Controlled heating of the box is arranged to give an accurate temperature at the required setting. Temperature control is achieved with a transistorized thermostat. The box is secured on pivot arms in such a manner that it may be raised and lowered on to a thermally-insulated working base.

The oven has a capacity of 1 cubic ft and incorporates a 275-W heating element.—*Contronics Ltd., Garth Works, Deepcut Bridge Road, Blackdown, Nr. Aldershot, Hants.*

**For further information circle 6 on Service Card**



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## 7. Conhex 'Slide-On' R.F. Connectors

THE CONHEX Connector Division of Sealectro Corporation are now marketing an addition to their range of radio-frequency connectors. This is the 'Slide-On' r.f. connector for sub-miniature cables with 50-Ω or 75-Ω

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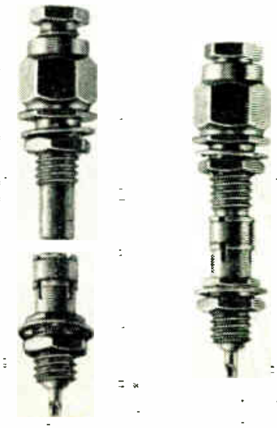

EQUIPMENT

# review


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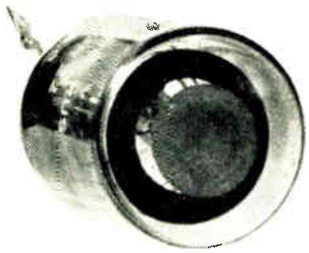
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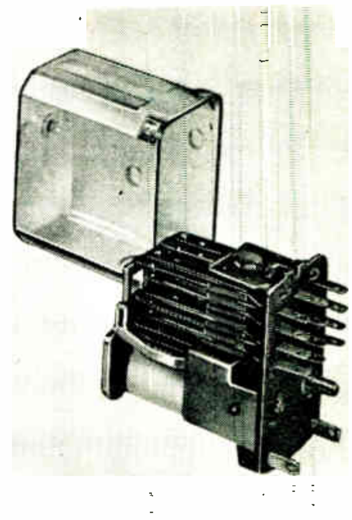
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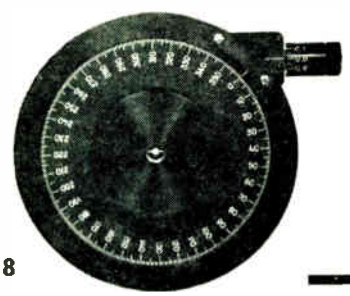
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impedance. The connectors are available in straight or right-angle assemblies and as bulkhead connectors. The connectors are machined from brass, they are gold plated and use Teflon insulation. They feature a factory adjusted pull-out strength ranging from 0·5 lb upwards.—*Sealectro Corporation, Hersham Factory Estate, Walton-on-Thames, Surrey.*

**For further information circle 7 on Service Card**

## 8. High-Resolution Dial Assembly

THETA INSTRUMENT CORP. of U.S.A. announce the availability of their Dial Assembly, Model DRR, offering easy readability and high accuracy. Featuring a readability of 0·025 degree (1·5 min-of-arc) for any angular position from 0° to 360° the Model DRR has an absolute accuracy of 0·1 degree (6 min-of-arc). Backlash is non-existent due to a unique mechanical design. A rapid-turning knob is connected directly to the output shaft; for high setting accuracy, the vernier knob is turned 360 times to produce a single output shaft revolution. The Dial Assembly mounts as a single unit to a panel of any gauge.

Any servo-mounted device may be plugged into the spring-loaded mount at the rear of the dial. Loads of 10 in.-oz, or greater if necessary, may be driven. A built-in slip clutch automatically disengages the mechanism when the load reaches its stop. Dial readings are easily zeroed with respect to the mounted transducer by means of a front adjustment. To assure zero slip there is positive clamping of the driven shaft.

The Model DRR is used for the angular positioning of synchros, potentiometers, encoders, and other shaft transducers. Its principal application is on control and test consoles.

Specifications: Continuous rotation, 0° through 360°. Accuracy, 0·1°. Readability, 0·025°. Ratio, direct knob to output shaft, 1 to 1. Ratio, vernier knob to output shaft, 360 to 1. 5 in. outside diameter. Weight, 1 lb.—*Theta Instrument Corp., 520 Victor Street, Saddle Brook, New Jersey, U.S.A.*

**For further information circle 8 on Service Card**

## 9. Electric Cable Lugs

THE LATEST additions to the range of Bowthorpe Electric overhead line equipment are Utilux cable lugs.

Manufactured from copper-alloy, these cable lugs are of the bolted type for quick termination of conductors and to ensure efficient mechanical and electrical installation.

Two important features of Utilux cable lugs are: (a) the palm is machined, so giving a better contact surface and, (b) the machined portion of the palm is raised above the level of the rest of the casting producing a good contact in all positions. They are suitable for cables of up to 0·6 sq. in. —*Bowthorpe Electric Co. Ltd., Gatwick Road, Crawley, Sussex.*

**For further information circle 9 on Service Card**

## 10. Touch-Controlled Relay Tube

A COLD CATHODE RELAY TUBE which can be controlled by touching an external electrode has been introduced by Cerberus A.G., Switzerland. Touching the control electrode brings it to earth potential and causes the tube to fire. The glow within the tube gives a clear visual indication when it is conducting. Life expectancy is in excess of 10,000 hours or 10 million firings.

In operation, the maximum anode-to-cathode sustaining potential is 85 V and the maximum cathode current is 15 mA.

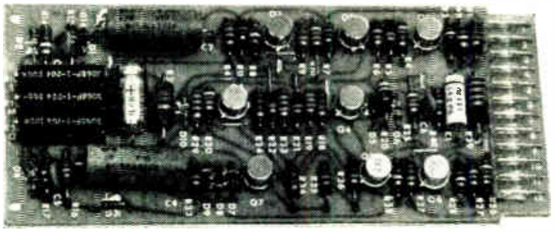
This new tube is intended for use in a wide range of control circuits.—*Walmore Electronics Ltd., 11–15 Betterton Street, London, W.C.2.*

**For further information circle 10 on Service Card**

## 11. Plug-in Relay from TMC

A PLUG-IN relay in the Zettler range of light-duty relays has now been introduced by Telephone Manufacturing Company Limited.

The relay is intended for incorporation in a variety of electronic circuits and will have a wide range of contacts and coils. The two changeover (Type



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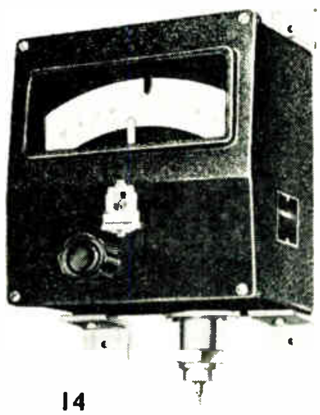

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AZ 420) and the four changeover (Type AZ 421) with 24-V coils are now in stock and available for immediate delivery.

An important and useful feature of this relay is that its plug base will fit the sockets of both British and Continental miniature relays of similar type.

The relay, which is for light-duty switching, weighs between 20-28 gm depending on contact arrangement, and without socket has a panel mounting height of 1·2 in.—*Telephone Manufacturing Co. Ltd., Martell Road, London, S.E.21.*

**For further information circle 11 on Service Card**

## 12. Line Quality Monitors

ATLANTIC RESEARCH CORPORATION OF U.S.A. have recently added a series of low-cost data quality monitors to their range of communications equipment for data and telegraph systems. Each unit is designed as a plug-in card-type monitor which can be individually set to warn of impending circuit troubles. Whenever the signal deteriorates in a circuit, the monitor assigned to that circuit automatically provides a warning signal.

The series of monitors cover 60 to 150 words per minute data transmissions and provide a wide range of distortion thresholds which may be selected by a simple screw adjustment. In addition to distortion alarms, the on-line monitor will announce an open-circuit line or a no-signal condition.

Twenty monitors may be mounted in a 19 in. × 3·5 in. rack.—*Atlantic Research Corporation, Shirley Highway at Edsall Road, Alexandria, Virginia, U.S.A.*

**For further information circle 12 on Service Card**

## 13. Electronic Timers

THE DONOVAN E.A.T.-10 series of electronic timers is designed for those applications in industry where it must be possible to set a process or delay time quickly and easily to a given value. The timers have a calibrated control dial continuously adjustable over a 15 to 1 time range (e.g. 0·1 sec to 1·5 sec).

A unique feature is that the linear calibration of the time control scale, with no cramping at either end, has been obtained while retaining a short reset time, and using a robust wire-wound potentiometer.

The E.A.T.-10 timer provides a single controlled time interval. It is possible to interconnect a number of units to provide a sequence of individually controllable time sequences from 0·1 to 500 sec.

It comprises a printed electronic circuit mounted on a standardized tray unit of cadmium-plated sheet steel. The tray unit can be supplied either in open form for building into other equipment, or with a robust dust and damp protecting cast light-alloy case having a stove-enamel hammer finish. Either form can be supplied with wired-in or plug-in terminations.

The control potentiometer can be mounted in the lid of the case, in which case the leads from the potentiometer are terminated in a plug which mates with a socket mounted on the electronic tray. Alternatively, the control potentiometer can be mounted in a remote control box.

The time interval is started by closing an external initiating contact and after a time determined by the setting of the timer control dial, the relay on the electronic tray operates. One normally-open and one normally-closed contact on this relay (rated to switch 5 A at 250 V or 1 A at 415 V a.c. unity power factor) are wired to the terminations. The built-in power supply for the unit comprises a double-wound transformer having a 415-V primary winding tapped for use also on 240-V single-phase a.c. 50/60 c/s supplies.

Supply voltage variations of +10% or −15% will not cause the timed interval to change more than ±2% of the full scale value.

The dimensions of the cast alloy box for the timer are $7\frac{3}{8}$ in. × $4\frac{15}{16}$ in. × $4\frac{15}{16}$ in.—*The Donovan Electrical Co. Ltd., Safuse Works, Northcote Road, Birmingham* 33.

**For further information circle 13 on Service Card**

## 14. Thermostats for Refrigerator Vans

THE LATEST electrical thermostat manufactured by The Partlow Corporation of U.S.A. has been specified by U.S. Fruit Growers Express Company as the temperature control to be used on 150 of its 40-ft vans with underslung refrigeration units.

The controller is called Model DW and is an electromechanical indicating instrument which incorporates three switches actuated in sequence by the expansion and contraction of its mercury-filled thermal system.

The Model DW was especially developed for refrigerated containers and vans and its features include a special high-visibility scale and two auxiliary switches which are used to change the cooling-heating cycles when the instrument is switched from perishable to frozen food service. Switch-actuating power is supplied by a thermal element which has a greatly reduced bulb size, almost linear scale increments and which provides for an expanded scale to allow for over-temperature protection from excessive ambients or steam cleaning.

The overall dial range is −30 to 170 °F. The high-visibility dial of the

# EQUIPMENT review

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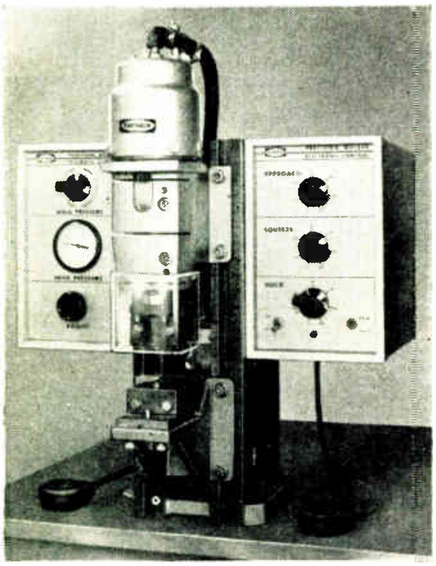

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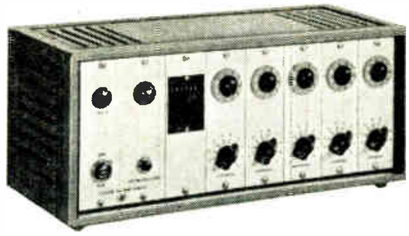

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instrument lets maintenance men readily monitor the temperature control of the trailers en route. The dial pointers and numerals are designed to be read accurately by torch light from a 10-ft distance. Complete specifications and prices are available from: *Ad. Auriema, Inc., 85 Broad Street, New York 4, New York, U.S.A.*

**For further information circle 14 on Service Card**

## 15. Production Welding Head

A RAYTHEON single-action pneumatic welding head designed for high speed precision welding of electronic sub-assemblies, capacitors, transistors, etc., is now available in Europe with an electronic timer.

This 'Weldpower' model M head incorporates a special air-operated chamber that automatically advances the top electrode to the work and a spring return for retracting the electrode.

The electronic timer controls approach, squeeze, weld and hold cycles. The duration of the approach, squeeze and hold cycles can each be set individually by control knobs which are mounted on the front of the timer. The electronic unit also incorporates a panel switch which permits a simplified selection of weld or electrode tip-dress and alignment.

The welder is designed for power supplies which are rated up to 3,000 W sec d.c. or 30 kVA d.c. The head has an adjustable forging force of 45 to 900 lb.—*Sorensen-Ard A.G., Eichstrasse 29, Zurich 3/45, Switzerland.*

**For further information circle 15 on Service Card**

## 16. Electronic Counter

BRITEC HAVE ANNOUNCED the Elesta electronic counter type IZ 301 A which incorporates decade counter-selector tubes and has a maximum counting rate of 100,000 c/s. This has been designed as an adaptable equipment with plug-in units consisting of various input, coupling and output stages which can be combined to suit most requirements. Typical applications include counting, batching, interval timing and time and frequency measurement.

The plug-in units include a range of decade stages, a high-sensitivity pre-amplifier, a 100-kc/s crystal-controlled oscillator reference stage, and a universal control stage with coincidence circuits. The counter can be operated from a suitable photo-diode pulse or contact inputs.—*Britec Ltd., 17 Charing Cross Road, London, W.C.2.*

**For further information circle 16 on Service Card**

## 17. Miniaturized Chart Recorder

AN EXTENSIVE range of miniaturized chart recorders and accessories is now being produced by Rustrak Instruments. The Rustrak recorder weighs only $3\frac{1}{2}$ lb, has dimensions $3\frac{1}{2}$-in. wide, $5\frac{1}{2}$-in. high × 4-in. deep, is housed is a rugged diecast aluminium case and incorporates a dry writing process that provides a clean permanent smudge-proof record even under extreme environmental conditions.

The clean functional design which recently won a design award in the U.S., has resulted in a robust high precision instrument being achieved at low cost.

Instruments are available operating from either mains or batteries, and chart speeds from $\frac{1}{4}$ in. to 60 in. per hour are available. A wide range of calibrations for current and voltage a.c. and d.c. and temperature is available, the most sensitive basic instrument having a 50-$\mu$A movement.

Standard accessories include multi-range adaptors which enable a single instrument to be used for 14 ranges and amplifiers which give full scale deflection on standard instruments for less than 1 $\mu$A d.c. The recorders are available in either single, dual or multi channel versions.—*Rustrak Instruments, Lower Bevendean, Brighton, 7, Sussex.*

**For further information circle 17 on Service Card**

## 18. Process Timers

ELREMCO have developed a motor-driven timing switch that closes one electrical circuit for a pre-set percentage of a fixed timing cycle. The timing action repeats itself continuously while the miniature synchronous motor of the unit is energized.

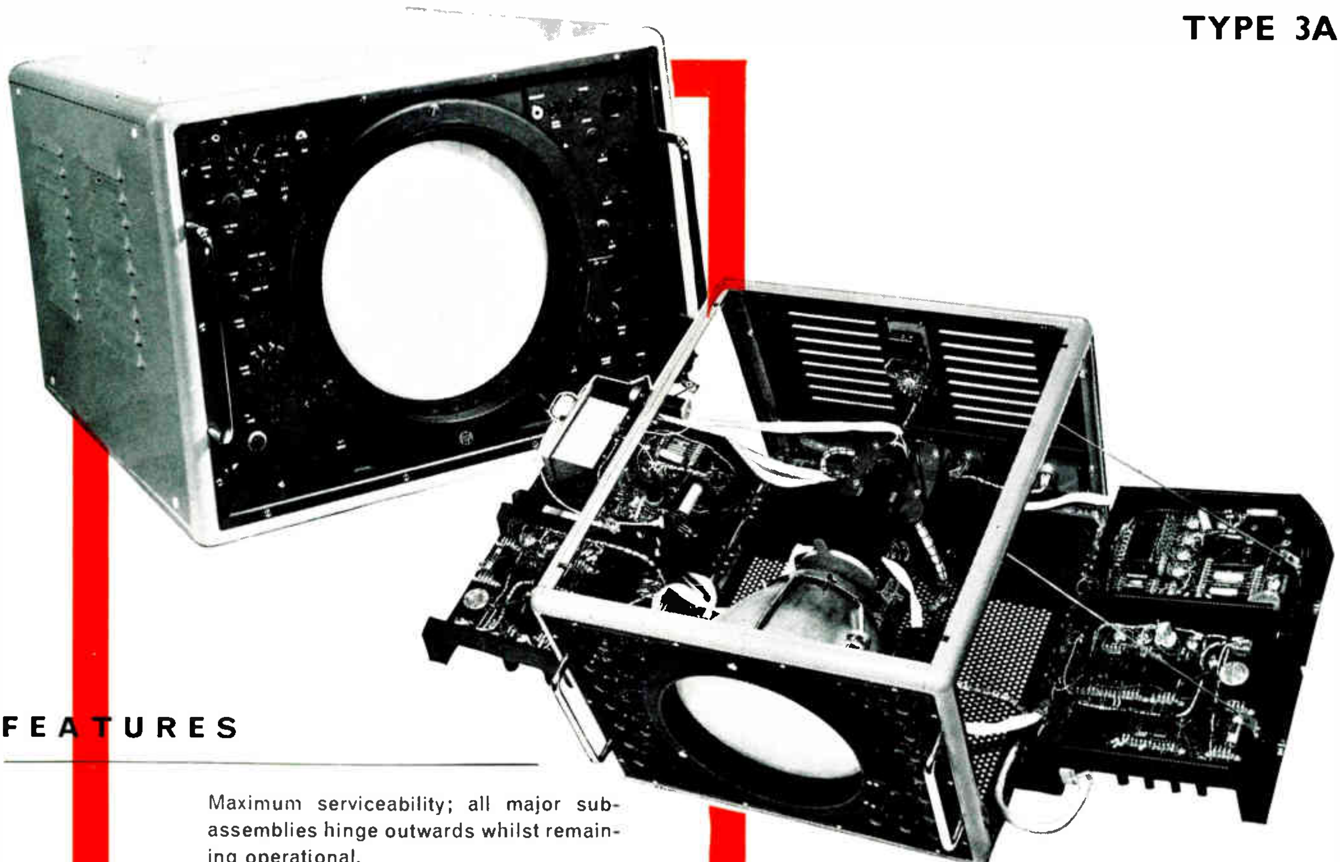
The unit is known as the Energy Controller Type PCS. It is driven by a built-in miniature synchronous motor through a pair of interchangeable gears. The percentage of the timing cycle during which the external switch-

(*Continued on page 41*)

For further information circle 227 on Service Card

# RADAR DISPLAY UNIT

## TYPE 3A



### FEATURES

Maximum serviceability; all major sub-assemblies hinge outwards whilst remaining operational.

Range continuously variable from 10 n.m. to 100 n.m. plus switched range extension.

Two independent shift systems allow centred or offset display instantly.

Rotatable parallel line cursor with 1° circumference etchings.

Cursor can be locked to provide fixed plotting surface.

Three independent sets of range marks facilities.

Additional channel for negative mixed video.

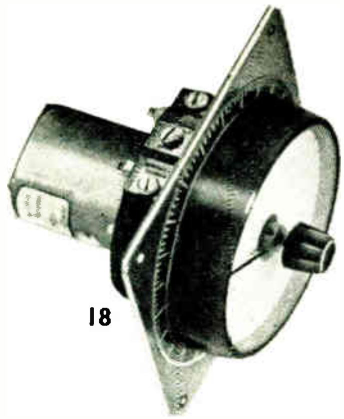
The Type 3A is a general compatability Radar Display of great flexibility although designed primarily for ATC use, it is also ideally suitable for Radar Simulators, Harbour Approach Systems etc and in any application where a PPI or offset display is required. The 12″ orange overlay tube permits daylight viewing.

**THE MOST TRUSTED NAME IN ELECTRONICS**

FOR FULL DETAILS AND SPECIFICATION PLEASE WRITE OR PHONE

**RCA GREAT BRITAIN LIMITED,** Sales Division, Lincoln Way, Windmill Road, Sunbury-on-Thames

ASSOCIATE COMPANY OF RADIO CORPORATION OF AMERICA. Telephone: Sunbury 5511



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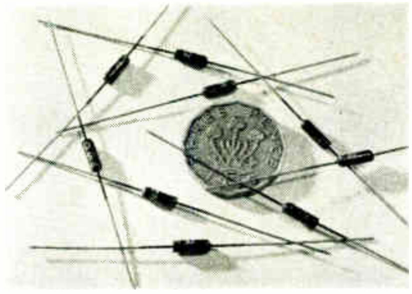

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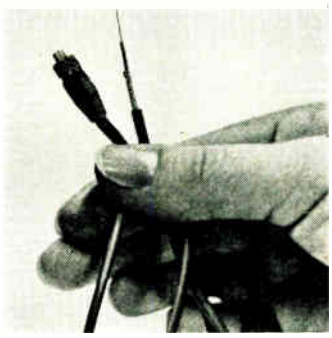

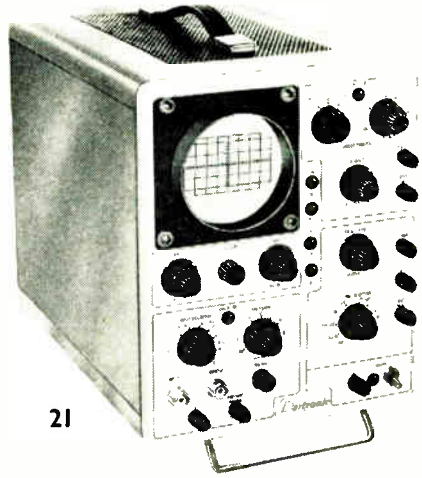

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ing circuit will be closed is pre-set by the turning of the front time-setting knob. The range of adjustment is 1 to 96%, and the standard timing cycles are 10, 30, and 60 sec and 6, 10, 30 and 60 min. The capacity of the switch is 15 A at 240 V a.c. or 3 A at 440 V a.c. (non-inductive).—*Electrical Remote Control Co. Ltd., Elremco Works, Bush Fair, Tye Green, Harlow New Town, Essex.*

**For further information circle 18 on Service Card**

### 19. Miniature High Voltage Rectifiers

A NEW SERIES of miniature double-diffused junction rectifiers with peak inverse voltage ratings of 2 kV and mean rectified current ratings of 100 mA at 25 °C is now available from the Electronics Department of Ferranti.

Of double-ended construction and with hermetically sealed glass encapsulation, the ZHS101 and ZHS102 rectifiers are claimed to be the only devices of their type available in Western Europe with such a low reverse leakage current as 0·03 μA at this high reverse voltage. The two types differ only in reverse current. The ZHS101 has a typical reverse current of 0·01 μA at 25 °C (1·5 μA at 100 °C) and the ZHS102 has a typical reverse current of 0·1 μA at 25 °C, and 5 μA at 100 °C at full p.i.v. rating. Both types measure only 2·7-mm diameter, and have a maximum overall length of 7·66 mm. They are suitable for use in temperatures from −55 °C to +150 °C.

The high voltage capabilities of these devices, coupled with their miniature glass construction allowing a maximum mean power dissipation of 300 mW, make them suitable for use in high voltage d.c. power supplies of 1 kV and higher by series assembly or in multiplier chains.

Supplies of both types are available immediately.—*Ferranti Ltd., Hollinwood, Lancs.*

**For further information circle 19 on Service Card**

### 20. Low-Noise Cable

GULTON INDUSTRIES are now marketing the full range of Gulton low-noise cable in this country.

The cable which has exceptionally low microphony, has been designed for use with accelerometers and other vibration-measuring transducers and it is claimed that it develops only 5% of the noise generated by standard coaxial cable. In addition it has exceptional flexibility in subminiature size. The low noise properties of the cable are achieved by the construction which is unique in so small a size cable. The fused p.t.f.e. insulation has a conductive coating which ensures a gradual transition from the insulation to the shield (screen) thus eliminating the abrupt changes in cable characteristics responsible for the majority of the noise in standard coaxial cable.

The cable is available in two temperature ratings; the high temperature type is suitable for continuous operation up to 280 °C, the standard type for continuous operation up to 150 °C. The external diameter is 0·111 in. and the capacitance is 36 pF/ft and a full range of mating connectors and adaptors is available if required.—*Gulton Industries (Britain) Ltd., 52 Regent Street, Brighton, Sussex.*

**For further information circle 20 on Service Card**

### 21. 4-in. Measuring Oscilloscope

RECENT ADDITIONS to the range of oscilloscopes which are being produced by Dartronic are the Models 415/417.

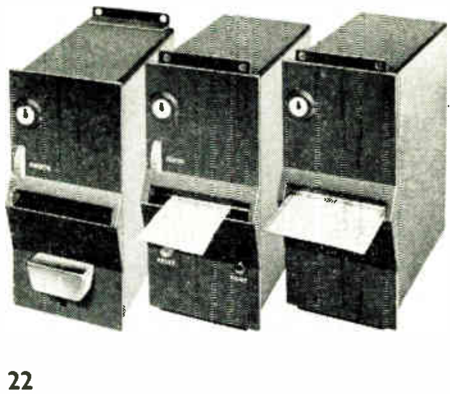
Model 415 is a wide-band general-purpose instrument with d.c. coupling, an internal pre-amplifier and many features which have in the past been incorporated in only the more expensive oscilloscopes. The maximum sensitivity is 10 mV/cm and the bandwidth is d.c. to 2 Mc/s. It is fitted with a 4-in. p.d.a. c.r.t. and includes stabilized power supplies, accurate voltage and time calibration, a wide sweep range and high writing speed. Other features provided are two signal inputs, beam-position indicators and a continuously variable vertical sensitivity control.

The Model 417 is identical to the

415, except that balanced delay lines are introduced into the vertical amplifier to permit the observation of the leading edge of the waveform triggering the sweep.—*Dartronic Ltd., 3-7 Windmill Lane, London, E.15.*

**For further information circle 21 on Service Card**

# EQUIPMENT review



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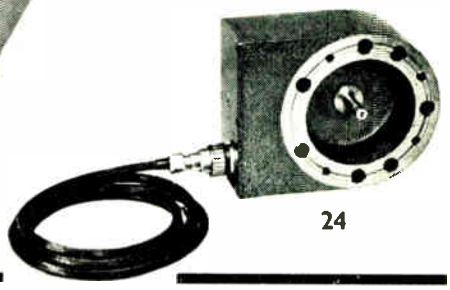

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## 22. Impulse Counters and Printers

A UNIQUE range of electrical impulse counters with print-out facilities has been designed by the English Numbering Machines Ltd.

These units have been produced to meet the demand for a method of obtaining a printed record in counting applications where hitherto only visual indication has been available. Applications for this unit include continuous data recording, delivered quantity recording for fluids, etc., recording production or machine operations, recording components and for stock control.

Standard versions of the counter are available for operation at 12, 24, 48 and 110 V d.c. and 115 V, 230 V 50 c/s and 115 V 60 c/s. Special counting, resetting and printing solenoids can be fitted for non-standard supplies from 6 to 110 V d.c. and 6 to 250 V, 50 or 60 c/s.

The counter readings are recorded on paper roll, single cards, or card and carbon sets; printing is electrically or manually operated.—*English Numbering Machines Ltd., 25 Queensway, Enfield, Middlesex.*

**For further information circle 22 on Service Card**

## 23. High Resolution Optical Encoders

A RANGE of optical shaft encoders has recently been introduced which combine resolution with low inertia and rugged construction. The instruments are manufactured by Winston Electronics and marketed by Digital Measurements.

These analogue-to-digital convertors give shaft angle in a variety of codes as required, such as Gray Binary, straight binary, decimal binary and cyclic progressive binary; other functions such as sine-cosine, sine$^2$ and latitude-longitude can also be supplied. The encoders can be used to monitor the rotation of radar aerials, stable platforms and weapon systems and have obvious applications to machine tool control and as digital position feedback elements in many kinds of servo systems.

The Winston-DM Encoder comprises a shaft-mounted glass disc carrying a coded pattern, printed by a special photographic process capable of extremely fine resolution. A lamp and optical system project a light beam through the disc on to photo detectors, arranged behind a slit, which produce a digital output dependent on angle of shaft rotation.

Using no brushes or contacts, and needing no gearing (external or internal) to achieve its high resolution, the Winston-DM Encoder is virtually unaffected by wear. Backlash and all significant friction are eliminated and the simple disc and shaft present a minimum moment of inertia. The design is extremely rugged and the lamp is under-run to give a maximum life factor; in situations of extreme shock, for example up to 50 *g*, double filament lamps are employed. For use in arduous conditions oil, water and dust-proof seals can be fitted to the shaft entry.

A range of instruments is available giving from 256 to 131,072 counts in 360°. The model illustrated is Type 1/13/23/BGC having a standard size 23 case of 2·3 in. diameter. This is a 13 bit device giving 8,192 counts per revolution and offers a readout rate of 350 r.p.m. though the shaft may be rotated at much higher speeds.

All Winston-DM Encoders have a bearing life of 100,000 hours at maximum speed and operate over the temperature range −20 to +70 °C; special models can be supplied for use beyond these limits.—*Digital Measurements Ltd., 25 Salisbury Grove, Mytchett, Aldershot, Hants.*

**For further information circle 23 on Service Card**

## 24. Rotary Impulse Transmitter and Counter

LINDARS AUTOMATION have developed a transmitter and counter as an improved alternative to a switched impulse source and electromagnetic counters. The two units may be used together in any field requiring impulses derived from a rotating movement such as quantity batching, machine tool control, automatic weighing, liquid metering and speed control although the counter can, of course, be used independently.

The impulse transmitter is of the non-contacting type running in ball bearings and consists of a rotating ring having from 10 to 100 magnetic elements each of which unbalances a bridge circuit so producing the equivalent number of impulses per revolution as elements in the ring.

Each element is calibrated to be equivalent to the unit to be counted (i.e., volume, weight, length, etc.) and as the element passes a ferrite bridge forming part of a transistorized circuit fitted in the case of the transmitter, the bridge unbalances and transmits an impulse to the counter.

The counter is fully-transistorized and stabilized against mains variation and comprises three or more 10-position setting switches to pre-set the number of units required.

The counter can be provided with two or more coincidence circuits so enabling early action to take place before the target count is reached. This facility is extremely useful when controlling the speed of a machine or to provide extreme accuracy when controlling high rates of flow.

If required, the counter can be supplied with in-line numerical display to show the amount set and the amount to go and further outlets can be provided for recording purposes.

The impulse transmitter and counter circuit have been certified by the Factory Inspectorate, Ministry of Labour and National Service, as Intrinsically Safe and can, therefore, be used in hazardous areas providing the counter itself is in a safe area.—*Lindars Automation Ltd., 143 Maple Road, Surbiton, Surrey.*

**For further information circle 24 on Service Card**

## 25. Audio-Visual Trainer

ONE OF THE very few, if not the only, audio-visual presentation unit which was designed initially for instructing assembly operators is now available with the necessary services from Audio Visual Methods Ltd. This is the Videosonic system which was originally developed by Hughes Aircraft Co., U.S.A., to provide assembly-line operators with step-by-step visual and audible instruction on the assembly of complex electronic equipment.

This is basically a self-contained portable unit which includes an automatic slide projector with a screen and a magnetic tape play-back unit. Also included is the necessary circuitry to provide complete synchronization between the audible and visual presentations.

For successful use of this training aid, the initial structure of any programme is devised by specialists in conjunction with the customer. Illustrations are produced along with a suitable tape recording to which the signal coding for synchronization is added.

When using the Videosonic unit, the operator being trained is presented automatically with audible instruction which is synchronized with a series of slides.—*Audio Visual Methods Ltd., Cordwallis Industrial Estate, Maidenhead, Berks.*

**For further information circle 25 on Service Card**

## 26. Large-Capacity High-Speed Memory

AMPEX announce that they now have in full production a high-speed, random access, core memory. This unit, the type LQ, has a cycle time of 1·5 μsec.

This random access, ferrite-core memory is being produced in 2,048, 4,096 and 8,192 word modules. Word lengths are up to 56 bits and operations may be conducted on full words or on partial words. Larger capacity memories may be obtained by using combinations of standard modules.

The system is compatible with current computer designs. It is intended as a remote module, in a free-standing, self-contained frame which holds the ferrite-core stacks, the associated circuits and the power supplies. Controls for starting, stopping and resetting the memory are usually located at the computer.

Address and information storage registers are self-contained within the memory. The core memory completes a full 'read-restore' or 'clear-write' cycle in 1·5 μsec. A split 'read' and 'write' cycle is completed in 1·85 μsec. On the 'read' operation, information is gated to the computer in 0·9 μsec from the beginning of the cycle; the remainder of the cycle being used for the restoration of the information word to its original address. All logic and voltage regulation control circuits are on printed plug-in cards for ease of maintenance.—*Ampex Great Britain Ltd., 72 Berkeley Avenue, Reading, Berks.*

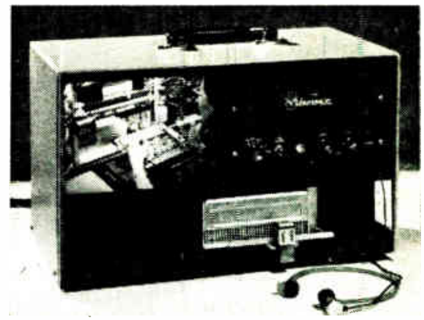
**For further information circle 26 on Service Card**

## 27. Plastic Cable Ducting

AN INTERESTING type of diagonally-slotted, rectangular ducting made of p.v.c. is now being imported by Shawford Control Gear Co. Ltd., under the name 'Duct-Plast'. Manufactured by 'CEMA', an Italian producer of equipment, it is available in 2-metre lengths, with cross sections of from 40 mm × 15 mm to 80 mm × 60 mm.

Among the advantages of the new ducting are its ability to retain its dimensions and characteristics over a wide range of ambient temperature, from − 20 °C to 150 °C. It is flame proof, completely non-hygroscopic and has exceptionally long life.

A feature of the 'Duct-Plast' is the



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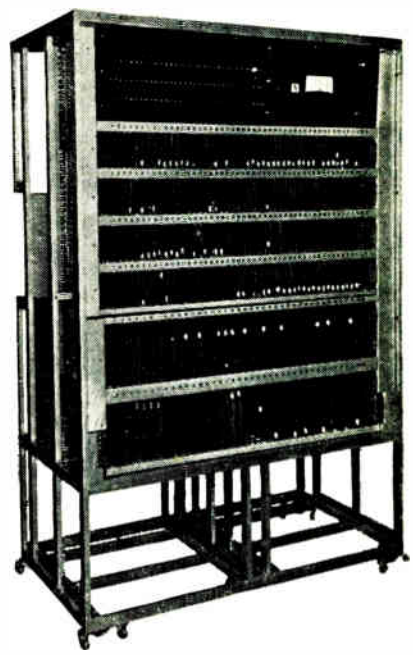

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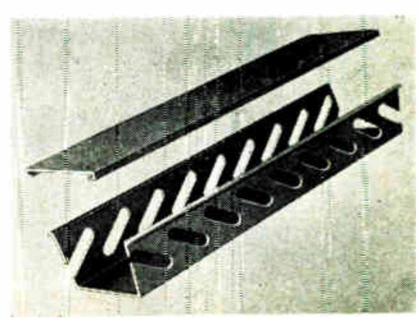
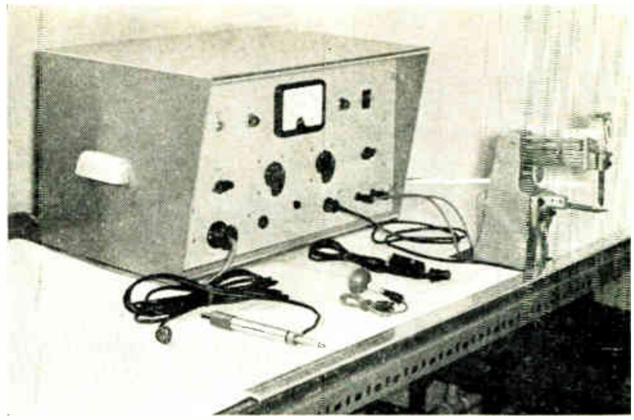


# EQUIPMENT review



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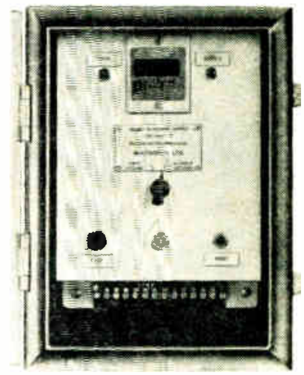

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snap-on cover that provides a close fit without the use of metal clips, and the more completely the ducting is filled with wires, the tighter the fit of the cover.—*Shawford Control Gear Co. Ltd., 715 Tudor Estate, Abbey Road, Park Royal, N.W.10.*

**For further information circle 27 on Service Card**

## 28. Capacitor Discharge Welding

SPEMBLY have now improved and extended their range of capacitor discharge welding equipment.

The latest version of the standard power pack is the Mk IIA and its range of application now covers not only fine wire welding and butt welding, but also spot welding of wires and thin foils.

Other power packs have also been added to the range, viz. Types WPM3, WEH3, and WPL3 and these, together with the accessories, are capable of welding similar or dissimilar wires of less than 0·0005-in. diam. with the WPL3, and up to 0·125-in. diam. with the WPM3 and WEH3 coupled together and using butt techniques.

All these power packs have voltage and capacitance regulation, 'fast charging' circuits, 'ready to weld' indication, manual and auto firing of the welding impulse, and facilities for bench or remote spot welding.

All previous accessories such as the Thermocouple Welding Unit, Butt Welder, etc., can be used with these packs, and the range of items now available also includes complete equipment for bench or remote spot welding of wires and thin sheet, up to a thickness of approx. 0·02 in.

Additional accessories include a bench-mounted, foot pedal operated, spot welding head, a remotely operated hand micro spot welder, and various types of connections for completing the welding circuit.—*Spembly Ltd., New Road Avenue, Chatham.*

**For further information circle 28 on Service Card**

## 29. Portable Pin-Hole Detector

A POCKET-SIZED pin-hole detector for finding coating defects without damaging surface textures, has been produced by Elco Instruments.

The instrument is contained in a laminated case measuring only 5 in. × 3 in. × $1\frac{1}{4}$ in. It is absolutely shock-proof and safe, operating on a 9-V P.P.3 battery.

It will detect holes in all coated surfaces on a metal base. The detection operation is fast and simple and is carried out by passing a wet sponge, connected to the instrument, over the surface to be tested.

At the top of the instrument case are two terminals separated by an on-off rotary switch. A lead from one terminal is connected by an insulated tube to a stainless steel bolt inserted through the centre of a cellulose sponge and held by two synthetic resin washers. The second lead is attached to the base material by a nickel-plated brass crocodile clip. The sponge is moistened with water, to which a small amount of detergent can be added to lessen surface tension, and the instrument switched on. The sponge, held by an ebonite handle, is passed over the surface to be tested and any pin-hole is immediately detected when water from the sponge makes contact with the metal, completing the circuit. Immediately such contact is made, the instrument emits a high-pitched note. If the pin-hole is particularly small, exact location can be traced by using the corner of the sponge.

Drainage of the battery is practically nil and a battery has been tested for over 40 hr at continuous oscillation. The instrument has the advantage over the normal brush electrode detector in that it does not operate on high voltages which have a tendency to break down coatings at thin points. Price of the pin-hole detector is £29.—*East Lancashire Chemical Co. Ltd., Elco Instruments Division, Fairfield, Manchester.*

**For further information circle 29 on Service Card**

## 30. Subminiature Soldering Iron

DEVELOPMENTS in the design of miniature soldering irons by 'Litesold' have made possible the production of two mains-operated irons. These are thought to be the smallest mains-operated irons in the world.

The first is model C10L which is a 10-W version and the second is model C15L which is rated at 15 W. The C10L is fitted with a $\frac{3}{32}$-in. diameter replaceable copper bit and the C15L has a $\frac{3}{16}$-in. diameter replaceable copper bit.—*Light Soldering Developments Ltd., 28 Sydenham Road, Croydon, Surrey.*

**For further information circle 30 on Service Card**

## 31. High-Speed Batching Counter

THIS EQUIPMENT employs a high-speed electromagnetic counter operated through a semiconductor circuit, and is capable of counting speeds up to 2,000 per minute and accurate batching speeds up to 400 per minute.

The input signal may be either from photocell, microswitch or microphone, etc., and as the duration of the signal is unimportant, small, fast moving objects may be counted precisely.

One of the features of the unit is that the output relay contacts can be selected to give either a brief operation at the end of each batch, or a complete change-over remaining so until the end of the next batch (as would be required for divertor flap control).

The basic electromagnetic counter counts down from a pre-determined number as manually pre-set by the operator; as it counts down, a row of numerals also moves to indicate the actual number counted at any instant. When the pre-determined number has been reached, the unit is electronically reset to the original batch number and an output signal is provided from the relay contacts. The actual counter itself can be quickly removed from the front panel and a replacement, if required, may be plugged in its place. Additional counters can be fitted as required for totalizing or giving batch numbers.

The unit is housed in a robust case with hinged door, which may be fitted with a lock, so that the indicator may be seen through a window but the setting cannot be altered by unauthorized personnel.—*Contronics Ltd., Garth Works, Deepcut Bridge Road, Blackdown, Nr. Aldershot, Hants.*

**For further information circle 31 on Service Card**

## 32. Pocket-Size Multimeter

TAYLOR ELECTRICAL have announced the release of an improved version of their 20,000 Ω/V pocket-size Multimeter Model 127A.

An important feature of the new model is the facility for measurement of high d.c. current. The instrument now has a special 'millivolt' socket and a range of plug-in miniature shunts are now available for readings of 1 A, 5 A and 10 A d.c. These shunts are designed to locate directly into the millivolt sockets incorporated in the Model 127A, thus forming a compact unit for measurement of high d.c. current.

A new type of 'ohms-adjust' control is now fitted which ensures greater stability and an improved type of a.c./d.c. selector switch is now incorporated.—*Taylor Electrical Instruments Ltd., Montrose Avenue, Slough, Bucks.*

**For further information circle 32 on Service Card**

## 33. Flexible Grommet Strip

HELLERMANN HAVE PRODUCED a flexible grommet material in strip form which is designed to line and grip odd-shaped holes.

This is known as 'Flexiform Grommets' and it is available in nylon or Teflon. The standard strip lengths are 12·75 in. for nylon and 19 in. for Teflon and the available colours are red, black, blue and natural nylon. The nylon version is recommended for applications at a temperature up to 135 °C; the Teflon can be used up to 260 °C.

Both the nylon and Teflon Flexiform Grommets range in sizes to fit material thicknesses from 0·015 in. to 0·51 in.—*Hellermann Ltd., Gatwick Road, Crawley, Sussex.*

**For further information circle 33 on Service Card**

## 34. B.I.C.C. Rotocrimp

THE Mineral Insulated Cables Division of B.I.C.C. have developed and produced an inexpensive, robust tool which considerably simplifies the final stage in M.I. cable termination. It is the B.I.C.C. Rotocrimp.

The B.I.C.C. Rotocrimp is designed to crimp the mouth of the brass sealing pot, after the latter has been filled with moisture-resisting compound, and to retain the sealing disc inside the mouth of the pot. It consists of a screw and a die plate, both of which are quickly removable if necessary for cleaning.

The body of the tool rests comfortably in the hand and can be held rigid when screwing down during the crimping operation. Virtually indestructible and capable of performing many thousands of individual crimps, the B.I.C.C. Rotocrimp is at present available for $\frac{3}{4}$ in. size terminations. It is now in stock (price 11s. net trade) at all B.I.C.C. Branch Offices.—*British Insulated Callender's Cables Ltd., 21 Bloomsbury Street, London, W.C.1.*

**For further information circle 34 on Service Card**

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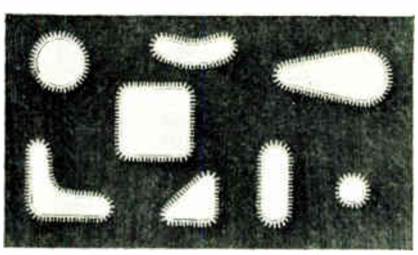

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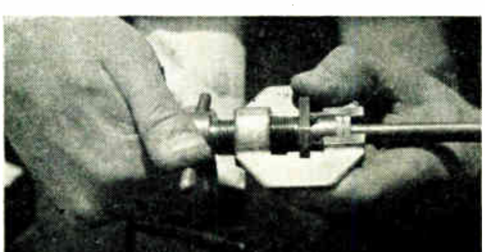

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# conversion loss in RECTIFIER MODULATORS

By D. P. HOWSON,* M.Sc.

**Rectifier modulator circuits are divided into two groups by their performance when the rectifier resistance is altered. It is shown that the one group—the double-tuned modulators—can be designed to have little conversion loss variation when either the forward or the reverse resistance of the rectifier changes appreciably. The remaining group of modulators is shown to be more suitable when both parameters change appreciably in the same direction, as with temperature variation. The use of feedback on both groups of modulators in order to minimize conversion-loss variation is also considered and it is shown that the double-tuned modulators are not so satisfactory in this application, but that with other types of modulator it is possible to produce a useful stable circuit.**

THE conversion loss of modulators made with semiconductor switches—rectifiers or transistors—may vary appreciably with temperature, or with the substitution of other elements with the same type number. Changes due to temperature may be caused by direct changes in the element parameters, or by indirect changes due to variations in the switching signal controlling the element. These temperature changes may be sufficiently large—in some communications test gear, for example—to be the limiting factor controlling the variation of gain with temperature of the whole equipment. Commercial semiconductor devices are such that there is an unavoidable wide spread of parameters, which will also cause changes of conversion loss that may be troublesome in equipment production and in equipment servicing.

The first section of this article, therefore, is concerned with assessing the variation of conversion loss for particular changes in element parameters in various modulation circuits. This is undertaken because it had been found that these circuits differ quite considerably in this respect, and thus it was felt that a more systematic study than has hitherto been made was called for. The effect of using values of terminating impedances differing from the low-frequency optimum is considered, and also the effect of change of element efficiency. Particular attention is paid to those circuits which have near-zero conversion loss.

It is shown that for all these circuits it is possible to choose the circuit impedances so that conversion-loss variations with temperature are minimized, but that this choice is not always of practical importance.

The second section of the article is concerned with the possibility of minimizing the conversion-loss variations by means of feedback. This has been done quite successfully with envelope modulators, but is more difficult when the modulators concerned operate as frequency changers, as in

* Electrical Engineering Department, University of Birmingham.

## LIST OF SYMBOLS

| | |
|---|---|
| $A$ | Conversion loss in dB. |
| $g(t)$ | $\sum_{m=0}^{\infty} g_m \cos m\omega_p t$, rectifier conductance. |
| $g_0, g_1$ | See $g(t)$. |
| $i_q$ | Current at frequency $\omega_q$. |
| $i_{n\pm}$ | Product current at frequency $n\omega_p \pm \omega_q$. |
| $n$ | $\sqrt{\frac{r_b}{r_f}}$ |
| $\rho$ | $\sqrt{r_b r_f}$ |
| $r(t)$ | $\sum_{m=0}^{\infty} r_m \cos m\omega_p t$, rectifier resistance. |
| $r_0, r_1$ | See $r(t)$. |
| $r_b$ | Reverse resistance of rectifier. |
| $r_f$ | Forward resistance of rectifier. |
| $R_s$ | Source resistance. |
| $R_l$ | Load resistance |
| $s$ | Mark/'mark + space' ratio of switching signal. |
| $\omega_p$ | Switching or carrier frequency. |
| $\omega_q$ | Signal frequency. |
| $\omega_p - \omega_q$ | Wanted product frequency. |

a superheterodyne. This paper considers only the possibility of applying feedback to frequency changers. Circuits have been proposed[3] in which all the modulation products of the frequency changer are fed back to the input via a buffer amplifier, but these require wideband circuits to keep the unavoidable distortion to a minimum, and are in any case not so successful as systems in which only one product is fed back. One such circuit[4] feeds back the wanted modulation product from the frequency-changer output to the input via an identical frequency changer, and it has been shown recently[5] that stabilization of gain is also possible in circuits using a single-balanced frequency changer by feeding back either the wanted product voltage or the voltage at signal frequency directly. Figs. 1 and 2 give block diagrams of the latter types of system. This article considers the last mentioned circuit, in which the modulator is included within the feedback loop of a preceding amplifier, in greater detail than before. It will be shown that although some forms of modulator that could be used in this circuit cannot be stabilized against all the possible parameter changes, it is possible to find others which can be so stabilized. Modulators in which the wanted product voltage is fed back directly have not been considered, since the analysis of them follows the same lines throughout. In general they are less useful than circuits employing feedback at signal frequency; the reasons being as follows.

(a) In most applications it is possible to use a less sharply selective filter to isolate the signal frequency than it is to isolate the wanted product frequency. This makes it easier to obtain stability in the system when the feedback loop is closed.

(b) With the type of circuit shown in Fig. 1(a) it is necessary to control the phase shift in the amplifier at two frequencies which may be widely separated. This is unnecessary in the circuit of Fig. 1(b), but this suffers from the disadvantage of restricting the dynamic range of the modulator.

The same assumptions have been made in this article as were made in a previous paper on single-balanced rectifier modulators,[6] namely that:

(i) the modulator circuits are linear, so that the switching of the elements is controlled entirely by the carrier signal, which is assumed to be square-wave.

(ii) the circuit impedances are either pure resistances or

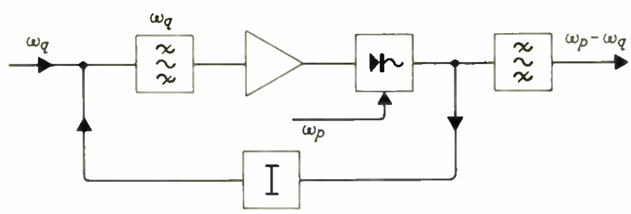



*Fig. 2.—Modulator circuit feeding back a component at frequency $\omega_q$*

sharply tuned, so that in the latter case they may be represented by different values of resistance at different frequencies. The significance of these assumptions was discussed previously.[6] The article will consider semiconductor rectifier diodes as the switching elements, although the analysis will also apply to any similar device capable of being switched from one resistive state to another.

### Effect of Changing Element Parameters

If the basic equations describing the performance of a rectifier modulator are examined,[6] it will be found that two parameters only are sufficient to define the particular rectifiers in use. These are the incremental or a.c. forward and reverse resistances of the element, $r_f$ and $r_b$. All that will be required therefore, in order to study the effects of variation of element

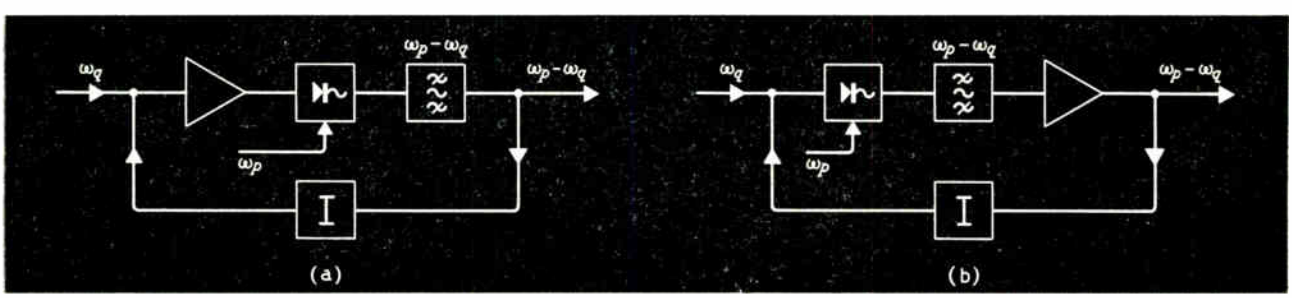



*Fig. 1.—Modulator circuit feeding back a component at frequency $\omega_p - \omega_q$*

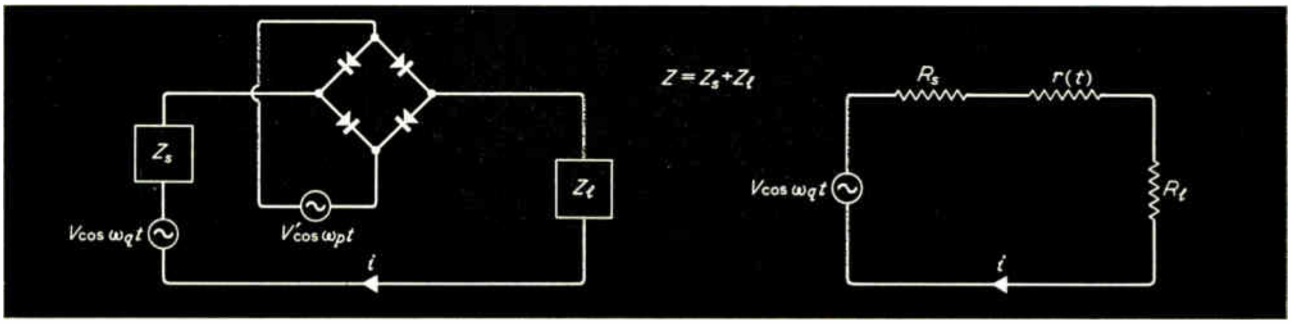



*Fig. 3.—The series modulator*

**Table 1**

| Series | | | Shunt | | | Ring | | |
|---|---|---|---|---|---|---|---|---|
| $R_s$ | $R_l$ | Type | $R_s$ | $R_l$ | Type | $R_s$ | $R_l$ | Type |
| $R$ at all freqs. | $R$ at all freqs. | 1 | $R$ at all freqs. | $R$ at all freqs. | 1D | $R$ at all freqs. | $R$ at all freqs. | 1 |
| $R$ at $\omega_q$, 0 elsewhere | 0 at $\omega_q$ $R$ elsewhere | 1 | $R$ at $\omega_q$ $\infty$ elsewhere | $\infty$ at $\omega_q$ $R$ elsewhere | 1D | $R$ at $\omega_q$, any value elsewhere | $R$ at all freqs. | 1 |
| 0 at $\omega_p-\omega_q$ $R$ elsewhere | $R$ at $\omega_p-\omega_q$ 0 elsewhere | 1 | $\infty$ at $\omega_p-\omega_q$ $R$ elsewhere | $R$ at $\omega_p-\omega_q$ $\infty$ elsewhere | 1D | $R$ at all freqs. | $R$ at $\omega_p-\omega_q$ any value elsewhere | 1 |
| $R$ at all freqs. | $2R$ at $\omega_p-\omega_q$ 0 elsewhere | 2 | $2R$ at all freqs. | $R$ at $\omega_p-\omega_q$ $\infty$ elsewhere | 2D | — | — | — |
| $R$ at all freqs. | 0 at $\omega_q$ $2R$ elsewhere | 2 | $2R$ at all freqs. | $\infty$ at $\omega_q$ $R$ elsewhere | 2D | — | — | — |
| $R$ at $\omega_q$ 0 elsewhere | 0 at $\omega_q$ $R$ at $\omega_p-\omega_q$ $\infty$ elsewhere | 3 | $R$ at $\omega_q$ $\infty$ elsewhere | $R$ at $\omega_p-\omega_q$ $\infty$ elsewhere | 3 | $R$ at $\omega_q$ $\infty$ elsewhere | $R$ at $\omega_p-\omega_q$ $\infty$ elsewhere | 3 |
| $R$ at $\omega_q$ 0 elsewhere | $R$ at $\omega_p-\omega_q$ 0 elsewhere | 3D | $R$ at $\omega_q$ $\infty$ at $\omega_p-\omega_q$ 0 elsewhere | $R$ at $\omega_p-\omega_q$ $\infty$ elsewhere | 3D | $R$ at $\omega_q$ 0 elsewhere | $R$ at $\omega_p-\omega_q$ 0 elsewhere | 3D |
| $\frac{2}{\pi}R$ at $\omega_q$ 0 at all odd products | $\frac{\pi}{2}R$ at $\omega_p-\omega_q$ | 4 | $\frac{2}{\pi}R$ at $\omega_q$ | $\frac{\pi}{2}R$ at $\omega_p-\omega_q$ | 4 | $\frac{2}{\pi}R$ at $\omega_q$ $\infty$ elsewhere | $\frac{\pi}{2}R$ at $\omega_p-\omega_q$ 0 elsewhere | 4 |
| $\infty$ at all even products | 0 elsewhere | | $\infty$ elsewhere | $\infty$ at all even products 0 elsewhere | | $\frac{\pi}{2}R$ at $\omega_q$ 0 elsewhere | $\frac{2}{\pi}R$ at $\omega_p-\omega_q$ $\infty$ elsewhere | 4 |

D signifies dual circuits.

parameters on conversion loss, will be an examination of how the conversion loss varies when first the value of $r_f$, and secondly the value of $r_b$ is changed. It has been found that when the temperature of a rectifier changes there is some relationship between the changes of $r_f$ and $r_b$, whereas when the element itself is changed these variations will be quite unrelated[3]—yet both effects will be calculable once the investigation just outlined is completed.

It has been shown previously[6] that the conversion loss of series, shunt and ring modulators may be derived from a single set of equations, when the mark-space ratio of the switching signal is 1 : 1. This has made it possible to base the calculations in this article solely on the series modulator, the basic circuit of which is shown in Fig. 3. A further simplification has been found possible, since some of the series-modulator circuits prove to be the dual of others[8] making it possible to deduce the results for these cases without separate calculation. It has therefore only been found necessary to examine four different circuits, the results for the other common forms of modulator being derivable by reference to Table 1. The conversion loss of three of these types is established in the literature, further simplifying the work.

**Modulator with Constant Resistance Terminations (1)**

The conversion loss of this modulator is known to be[6]

$$A = 20 \log \left\{ \pi \frac{R^2 + R(r_b + r_f) + r_b r_f}{(r_b - r_f)R} \right\} \quad (1)$$

when the modulator has equal source and load resistances, each $R/2$. Fig. 4 illustrates the change in this conversion loss when either the forward or the reverse resistance of the rectifier is varied by a factor of 10, for two different rectifier efficiencies. The rectifier with the greatest efficiency is clearly to be preferred, as a change in either resistance parameter produces a much smaller change of conversion loss in the corresponding modulator circuit. It is of interest to note that the changes due to the two parameters are equal when the circuit resistances are optimum; i.e., lead to the least conversion loss. Further, that if—as is often the case—the particular rectifier and switching circuit are such that the change of one parameter with temperature is much greater than that of the other, a suitable choice of terminating resistance can make the corresponding conversion loss change very small.

## Modulator with Source Constant Resistance, Load Antiresonant at Wanted Product Frequency (2)

The conversion loss of this modulator[7] is

$$A = 20\log\left\{\frac{\pi}{2}\sqrt{2}\,.\,\frac{3R^2 + 2R(r_b + r_f) + r_b r_f}{R(r_b - r_f)}\right\} \qquad (2)$$

when the load impedance at wanted product frequency is $2R$ and the source resistance is $R$. This relationship between source and load resistance is known to give minimum conversion loss. The expression is clearly of the same form as (1), only differing in the constants, and in fact this modulator behaves in almost the same way as the constant-resistance modulator, as may be seen from Fig. 4. If now the load of this modulator is changed to a circuit resonant at signal frequency, and of zero impedance at this frequency, but being of resistance $2R$ at all product frequencies, the equation (2) for conversion loss is unchanged and the same results follow. (It should be noted that the circuits are not alike in all respects, as the number and magnitude of the unwanted modulation products in the two cases differ.) There are dual shunt modulator circuits corresponding to both of the above.

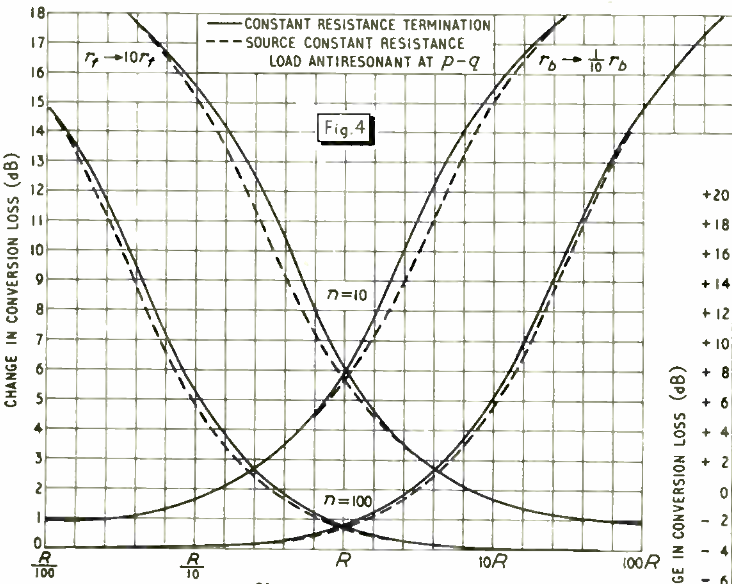



*Fig. 4.—Change in conversion loss for modulators (1) and (2).*

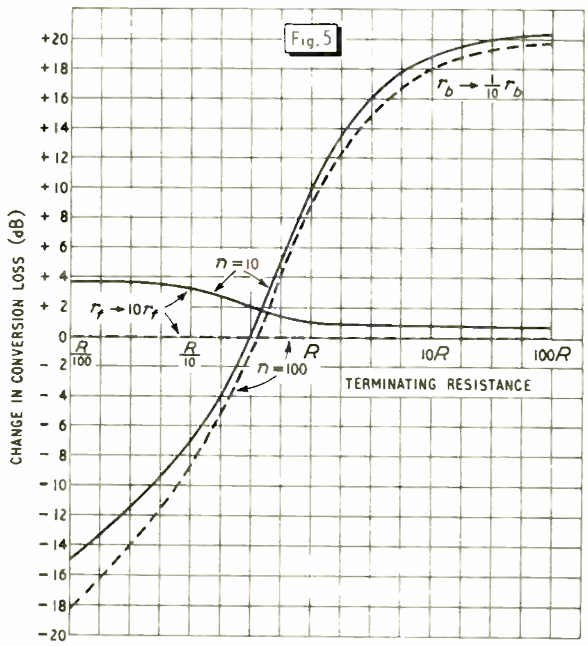



*Fig. 5.—Change in conversion loss for modulators (3).*

## Modulator with Terminations High Impedance to Unwanted Product Currents (3)

In this case, for the series modulator it is necessary to assume the rather awkward terminations

$$R_s = \begin{cases} R \text{ at } \omega_q \\ 0 \text{ elsewhere} \end{cases} \qquad R_1 = \begin{cases} 0 \text{ at } \omega_q \\ R \text{ at } \omega_p - \omega_q \\ \infty \text{ elsewhere} \end{cases} \qquad (3)$$

although there is a corresponding shunt modulator leading to exactly the same results with simpler terminating impedances. The conversion loss here is given by[6]

$$A = 20\log\left\{\frac{\pi}{2}\,\frac{R^2 + R(r_b - r_f) + 0{\cdot}15\, r_b^2}{R(r_b - r_f)}\right\} \qquad (4)$$

when the source and load resistances are equal, as is the case for minimum conversion loss. This equation gives quite different results from the previous expressions for conversion loss, mainly because the third term in the numerator, $0{\cdot}15\, r_b^2$, is very much larger than the corresponding term in the other expressions, $r_b r_f$, and of course does not contain $r_f$. The resulting changes for this modulator are given in Fig. 5. Clearly it is possible to keep variations in conversion loss due to changes in forward resistance to a minimum using this modulator, particularly if a highly efficient rectifier can be used. However, the variations due to changes in reverse resistance are comparatively large, and little affected by the rectifier efficiency. Note that it is possible for terminations less than the optimum to improve the conversion loss in this modulator while reducing the rectifier efficiency by lowering the reverse resistance. This is because the modulator conversion loss increases rapidly if the terminating impedances are changed from their optimum values, which is not so for the other forms of modulator discussed. Thus while the rectifier efficiency is reduced, leading to an increase in conversion loss, the termination mismatch is also reduced, leading to a decrease in conversion loss, and the latter effect is much greater than the former.

The series modulator with low impedance to unwanted product frequencies is the dual of the above, and therefore will be relatively insensitive to changes in the reverse

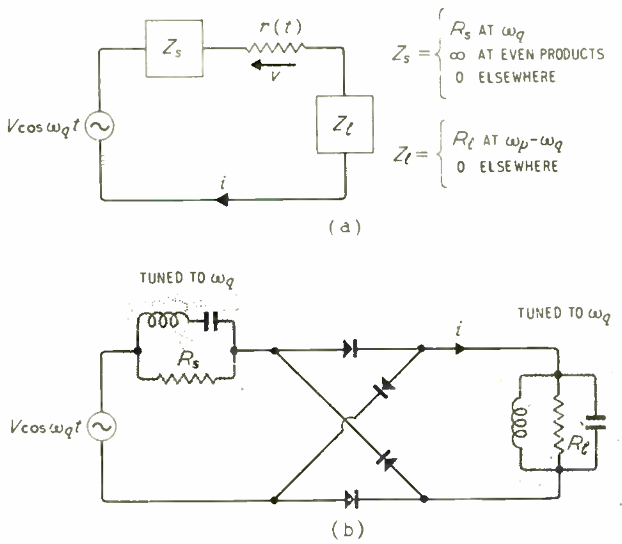



*Fig. 6.—The 'Zero-Loss' modulator*

$$Z_s = \begin{cases} R_s \text{ at } \omega_q \\ \infty \text{ at even products} \\ 0 \text{ elsewhere} \end{cases} \qquad Z_l = \begin{cases} R_l \text{ at } \omega_p - \omega_q \\ \\ 0 \text{ elsewhere} \end{cases}$$

the results will apply to the shunt and ring versions equally well[7]. The circuits are shown in Fig. 6. From this,

$$V = i_o R_s + i_{1-} R_l + v \tag{5}$$

and since $i = v\,g(t)$,

$$i_o = (V - i_o R_s) g_o - \tfrac{1}{2} i_{1-} R_l g_1 \tag{6}$$

Since $v = i\,r(t)$

$$v_{1-} = \tfrac{1}{2} i_o r_1 + i_{1-} r_o = -i_{1-} R_l \tag{7}$$

thus

$$i_{1-}\{(R_l + r_o)(1 + g_o R_s) - \tfrac{1}{4} R_l g_1 r_1\} = \tfrac{1}{2} r_1 V g_o \tag{8}$$

Since $r_o \simeq \dfrac{n\rho}{2}$

$$g_o \simeq \frac{n}{2\rho},\; r_1 \simeq \frac{2}{\pi}\rho n,\; g_1 \simeq -\frac{2}{\pi}\frac{n}{\rho},$$

$$i_{1-}\left\{\frac{\pi}{2}R_s + \frac{2}{\pi}R_l + \pi\frac{R_s R_l}{r_b} + \pi r_f + 2\pi R_l \frac{r_f}{r_b}\right\} = V \tag{9}$$

From this it may be shown that the conversion loss is a minimum when

$$\frac{\pi}{2}R_s = \frac{2}{\pi}R_l = \sqrt{r_b r_f}$$

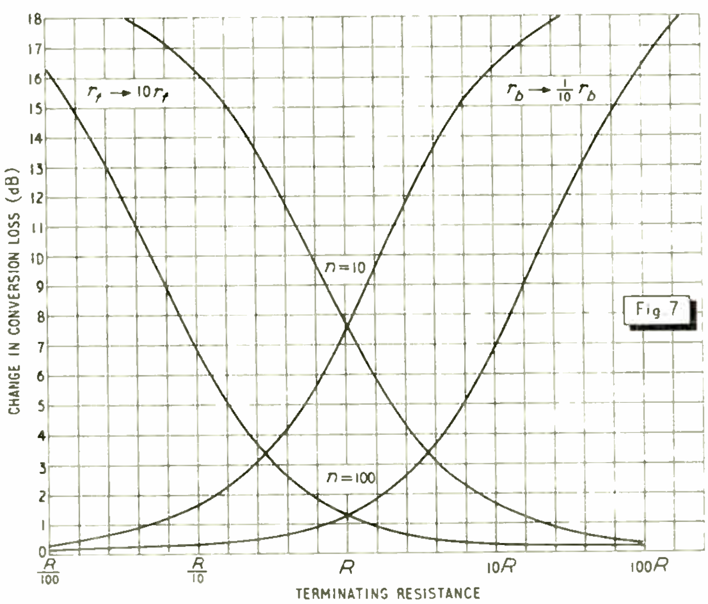



*Fig. 7.—Change in conversion loss for modulators (4).*

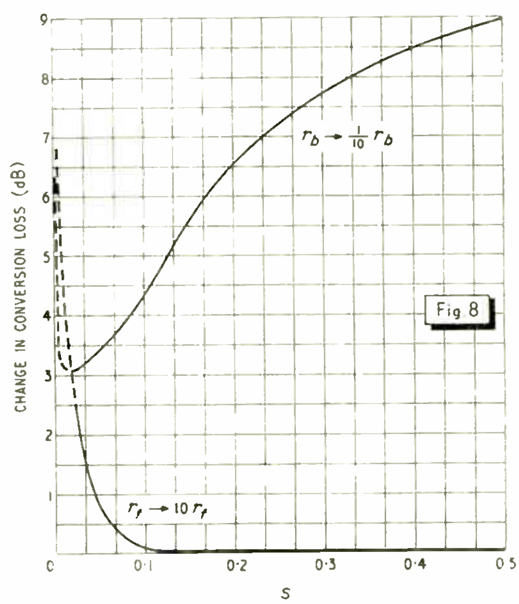



*Fig. 8.—Change in conversion loss for modulators (5).*

resistance. There is a corresponding shunt modulator, and there are ring modulators of both the types mentioned in this section.

**The 'Zero-Loss' Modulator (4)**

This modulator would give no conversion loss with perfect rectifiers, and it is quite possible to build a ring modulator that approximates closely to this type. The terminations for the corresponding series modulator are however complicated and it is unlikely that such a modulator would find practical application—nevertheless it will be analysed, since

and the variation of conversion loss for parameter changes may be calculated directly from (9), since, as conversion loss is defined as

$$A = 20 \log \left\{\frac{V}{2 i_{1-} \sqrt{(R_s R_l)}}\right\} \tag{10}$$

it is clear that $i_{1-}$ is the only term that varies. Fig. 7 shows the results of these calculations. The modulator behaves in a similar manner to the first two types investigated but the variations are in all cases a little greater.

### A More Practical 'Zero-Loss' Series Modulator (5)

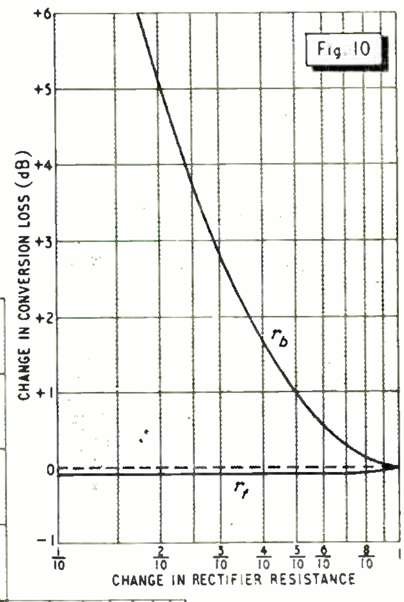
It is possible to make series or shunt modulators with very low conversion loss, being only limited, as in the last case, by the rectifier efficiency. The termination need not be complicated, being either high or low impedance at all unwanted product frequencies, but it is necessary to have a switching signal with mark-space ratio either nearly zero or very large. This has been discussed previously,[6,7] and it is only the resulting conversion loss formula that is of interest here. For the series modulator with high impedance terminations to unwanted products, this is

$$A = 20 \log\left\{\frac{\pi}{\sin \pi s}\,\frac{[R+r_f+s(r_b-r_f)]^2-\left[(r_b-r_f)\dfrac{\sin \pi s}{\pi}\right]^2}{2R(r_b-r_f)}\right\} \quad (11)$$

and the optimum terminating resistance is

$$R = R_s = R_l = \sqrt{\left\{(r_b-r_f)^2.\left(s^2-\frac{\sin^2 \pi s}{\pi^2}\right)-2(r_b-r_f)sr_f+r_f^2\right\}} \quad (12)$$

Fig. 8 illustrates the variation in conversion loss for parameter changes for $n = 100$, when the terminations are always optimum, and the ratio of 'mark' to 'mark + space' for the switching signal is varied. The conversion loss may be shown to be a minimum when its variation is the same whichever parameter is varied in this case when $s = 0{\cdot}02$: this brings this modulator into line with the other types previously discussed, but only let it be noted when the mark-space ratio is allowed to be a variable. Even so, under these conditions the variation in conversion loss is much greater than for these other types.



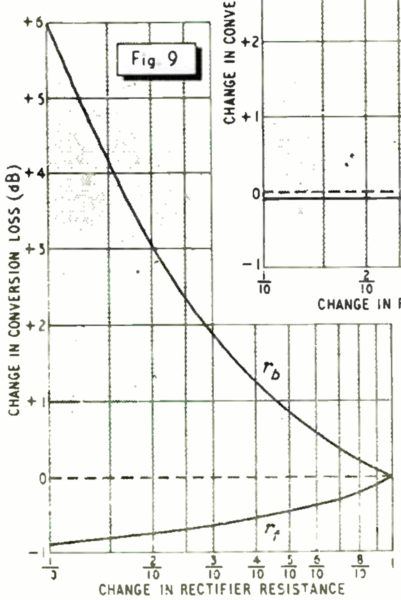




*Fig. 9.—Effect of resistance changes on a constant-resistance modulator*

*Fig. 10.—Effect of resistance changes on a double-tuned modulator*

**INFORMATION WANTED?**

If you require further details of products or processes described or advertised in INDUSTRIAL ELECTRONICS you will find it convenient to use the enquiry cards which will be found in the front and back of the journal.

### Effects of Temperature Change

Tucker has stated that, for all forms of rectifier known to him, the temperature changes of the forward and reverse resistances are in the same direction, and that their ratio is not greater than $n^2$. He has shown for two types of modulator that under these conditions it is possible to make the conversion loss independent of temperature change for incremental variations of rectifier resistance. Finally, he has shown that if the forward and reverse resistances have equal percentage incremental variations the modulator will have maximum stability when its terminating impedances are such as to give minimum conversion loss.[3]

For temperature changes of 20–40 °C, however, which must be considered in much equipment design, the change in rectifier resistances is considerable, and may be as high as the factor of ten considered in Figs. 4, 5, 7 and 8. Unfortunately it is not possible to predict from the results mentioned above how maximum stability of conversion loss may be attained, as can be seen from Figs. 9 and 10. These depict the effects of parameter change on a constant-resistance and double-tuned modulator respectively, in both cases the terminating impedances being chosen for minimum loss. The fact that the curves for variations of $r_f$ and $r_b$ differ so much in shape (for either modulator) indicates that if the terminations were arranged so that the conversion loss were constant for a particular temperature change, a lesser or greater change would produce a substantial error. This would be less in the case of the constant-resistance modulator, as can be seen by inspection of the curves. From the results of the previous sections it would appear that all other modulators would give results similar to the constant-resistance modulator except the double-tuned modulators with terminations of high impedance to unwanted product currents. A rough approximation which brings out this point is to consider that the change in rectifier resistance only affects the efficiency of the rectifier, neglecting the mismatching effect. Results for modulator conversion loss including a correction term for rectifier efficiency are available,[3] and from these it may be seen that the conversion loss ratio is modified by a term $k/n$ for the constant-resistance and allied modulators, but by a term $k/n^2$ for the double-tuned modulators ($k$ is a constant specific to each modulator). Substitution in these formulae of the appropriate values of $r_f$ and $r_b$ gives curves of the general shape of Figs. 9 and 10.

It must be concluded, however, from the results of this section, that little reduction in the sensitivity of modulators to large changes in ambient temperature may be obtained. Since also to obtain the matching required to get some reduction will necessitate selection of rectifiers for particular values of forward and reverse resistance, there still seems room for some quite different approach to the problem. One such approach will next be discussed.

*(To be concluded.)*

# INDUSTRIAL NEWS

## Personal and Company News

**C. O. Stanley,** president of the British Radio Equipment Manufacturers' Association and Chairman of the Pye Group of companies, has been elected chairman of the Radio Industry Council in succession to J. W. Ridgeway. **A. L. Sutherland** continues as vice-chairman.

**The Plessey Co. (U.K.) Ltd.** have formed separate divisions to handle the manufacture and marketing of resistors and capacitors. All resistors are manufactured at Cheney Manor, Swindon, where the marketing organization is also located. J. R. Clark is divisional manager, R. J. Buckley is sales manager and B. Lloyd is sales office manager. Capacitors are manufactured and marketed at Kembrey Street, Swindon. F. K. Poulton is divisional manager, A. A. Evans is sales manager and R. Gregory is sales office manager.

**G. D. Speake,** M.A., has been appointed Chief of Research of Marconi's Wireless Telegraph Co. Ltd., following the appointment of E. Eastwood, C.B.E., Ph.D., M.Sc., M.I.E.E., as Group Director of Research to the English Electric Group of Companies.

**Microcell Ltd.** has received a contract from Imperial Chemical Industries Ltd. for the provision of a 288-channel scanner-controller for a new process plant. The apparatus is to scan thermocouples located in the plant at the rate of 20 per second. Successive outputs will feed duplicated peak seeking and holding units which will retain the peak voltage obtained in any one scan to control the process plant.

**Reliance Controls Ltd.** is the new name of Reliance Manufacturing Co. (Southwark) Ltd. The change does not indicate any alteration in the trading and development policies of the company nor of its control. Address:—Relcon Works, Sutherland Road, Walthamstow, London, E.17. Telephone: Larkswood 8404-7.

The Scottish service depot for **Thorn-A.E.I.** cathode-ray tubes has moved to 151 North Street, Glasgow, C.3 (Telephone: Glasgow Central 2206).

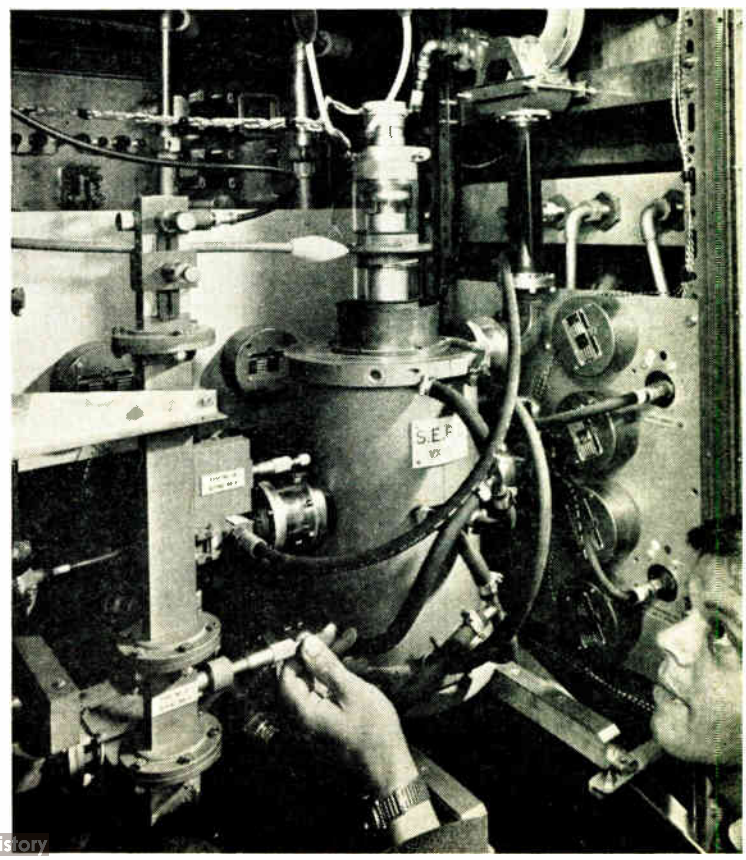
**J. Langham Thompson** has resigned from the board of Ether Langham Thompson Ltd. and from the boards of its subsidiary companies, including J. Langham Thompson Ltd., which he founded in 1946 and of which he was chairman and managing director.

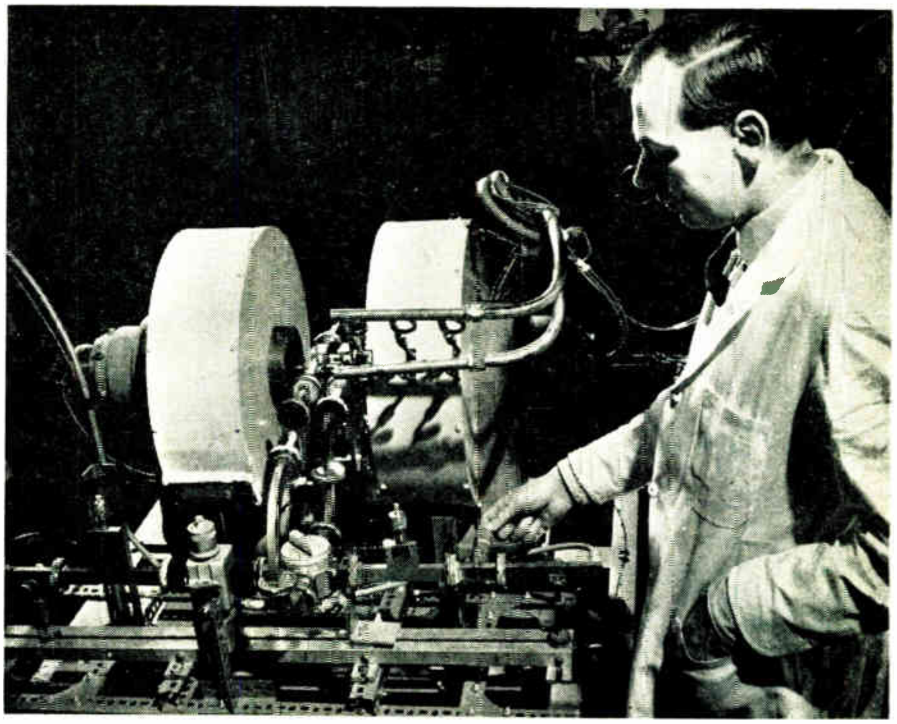
**Geoscience Instruments Europe** is a new firm specializing in equipment, supplies and technique for preparing critical surfaces; that is, high precision perfectly polished surfaces. The Supply Division deals with alumina abrasives and equipment for lapping and polishing. The Materials Processing Laboratory deals with the fabrication of semiconductors to specification and there are facilities for slicing, lapping and polishing silicon crystals, laser rods and ferrite components. The address is Taarnbyvej 43, Kastrup, Denmark (Telephone: 507543).

To assist industry in applying automation and control techniques a new company has been formed, **Livingston Control Ltd.** It acts as agents for equipment, as a design and manufacturing team for custom-built equipment, and as an information service. The directors are:—F. Livingston Hogg, M.I.E.E., M.Brit.I.R.E. (chairman), D. C. Rennie, A.M.I.E.E. (managing) and E. P. Roe, M.A., A.M.I.E.E. (technical). Address:—Retcar Street, London, N.19 (Telephone: Archway 6251).

**Digital Measurements Ltd.** have been appointed sole European agents for the Military and Computor Electronics Corporation (MACE) of Florida, U.S.A. Their address is 25 Salisbury Grove, Mytchett, Aldershot, Hants. (Telephone: Farnborough 2634).

*The picture shows part of the Goonhilly transmitter used in the Telstar experiments. In the centre is a travelling-wave tube developed by the Services Electronic Research Laboratory with an output of 4 kW at 6,390 Mc/s and a bandwidth of 100 Mc/s. Surrounding it are the power supplies and air and water cooling systems which have been designed and manufactured by Associated Electrical Industries Ltd.*





*A new microwave amplifier operating in the Hirst Research Centre of the General Electric Co. Ltd. Electromagnetic waves are propagated through a plasma of ionized gas at a velocity matched to that of an electron beam. As in a travelling-wave tube this gives a condition which favours the conversion of beam energy into electromagnetic waves*

**Mullard** have established a Technical Information Department to carry out all the functions previously performed by the Data and Publications Section. H. P. White, B.Sc., is the manager.

**Oswald King & Co. Ltd.,** the Midland agent of United Insulator, the ceramic division of the Telegraph Condenser Co. Ltd., have moved to 325 Hagley Road, Edgbaston, Birmingham 17.

**P. Antony Clayton,** marketing consultant, is changing his address to 275A Ewell Road, Tolworth, Surrey, as from 1st October.

## Obituary

Simeon M. Aisenstein died on 3rd September at the age of 78. Born at Kiev in 1884 he became interested in wireless as a boy and in 1905 he had an experimental laboratory. The Russian military authorities became interested and helped him ; in 1907 a company was formed with which Sir Isaac Shoenberg, Vladimir Zworykin and Ilia Mouromsteff were associated.

In 1911 this company merged with the Marconi Co. Mr. Aisenstein remained as director and during the 1914–18 war he was responsible for all Russian high-power stations. He was imprisoned when the Russian revolution occurred in 1917 but managed to get to England in 1921. In 1922 he became associated with a Polish company, Radiopol, of which the main shareholders were Marconi's Wireless Telegraph Co. Ltd. and the Société Française de Telegraphie sans Fils. In 1930 this company was dissolved and replaced by the Polski Zaklady Marconi. In 1935 Mr. Aisenstein left this organization to start another valve company, Radioslavia, in Czechoslovakia. He left in 1939 and went to Marconi's at Chelmsford where he was engaged in radio equipment design. In 1941 he took over the valve laboratories and in 1947, when the English Electric Valve Co. was formed, he became general manager, until his retirement in 1955.

## Radio Stereophony

The B.B.C. has been making experimental stereophonic transmissions since 1958 using the sound transmissions of television stations for the right-hand channel and the medium wave and v.h.f. Third Programme transmitters for the left-hand.

A new series of tests is to continue for ten weeks from 28th August using the Zenith-G.E. system. This needs only one transmitter and for this the Wrotham Third Programme transmitter (91·3 Mc/s) is used with an effective radiated power of 120 kW. The transmission times are:—midnight Tuesday-00.25 Wednesday ; 10.50-11.10 Wednesday morning ; midnight Wednesday-00.25 Thursday ; and 10.50-11.10 Saturday morning.

The main carrier will be deviated in frequency by a percentage of ± 75 kc/s. The peak deviation for the sum of the left and right signals is 90% with a peak deviation of 90% for a 38-kc/s sub-carrier and one of 8-10% for a 19-kc/s pilot signal. The sub-carrier comprises a suppressed sub-carrier amplitude modulated by the difference between the left and right signals.

## Ultrasonics

A new journal, *Ultrasonics*, will be published by Iliffe Industrial Publications Ltd. and the first issue will be dated January 1963. Published quarterly, the annual subscription rate is £4 (home and overseas) or $12 (U.S.A. and Canada). The journal will cover the principles and practice of ultrasonic and allied technology.

**For further information circle 44 on Service Card**

## I.R.E.-A.I.E.E. Merger

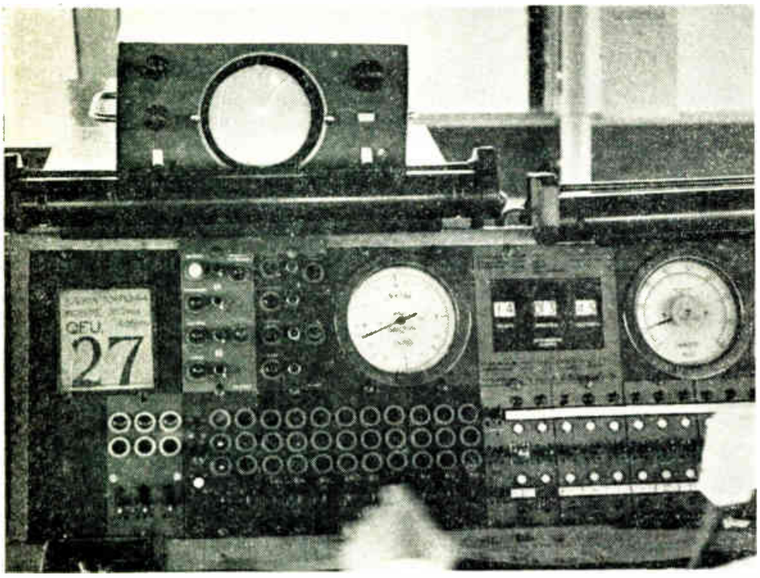
The plan for the merging of the Institute of Radio Engineers and the American Institute of Electrical Engineers has now been approved by the members of both bodies. The new body will be called the Institute of Electronic and Electrical Engineers (I.E.E.E.) and will come into being on 1st January 1963.

## New Radar Display

A radar display is required to present a picture which persists for several scans so that moving objects present a 'tail' which indicates their speed and direction of movement. Normal cathode-ray tube phosphors of long persistence do not give a large light output and it is usually necessary, therefore, to view the display in rather dim ambient lighting.

A new tube recently installed at Gatwick Airport by Marconi's Wireless Telegraph Co. Ltd. gives a bright enough picture for viewing in well lit areas. The tube is the English Electric E 702. The viewing screen has a high-efficiency short-persistence phosphor on the inside of the glass face-plate. There is a storage element, immediately behind the phosphor, which comprises a very fine metal mesh with a layer of dielectric material deposited on the side farthest from the phosphor.

There are two electron guns. One is a normal gun, the writing gun, which produces a beam of high velocity electrons. This is modulated and deflected in the usual way.




*The Marconi bright radar approach display unit on trial in Gatwick Control Tower*

The other is a flood gun. It provides a stream of low-velocity electrons which pass through collimating electrodes so that the storage mesh is uniformly covered by them.

These flood electrons produce secondary emission from the mesh, but there are fewer secondaries than primary electrons. The mesh potential thus becomes negative and the flood electrons cannot penetrate the mesh to reach the screen.

The high velocity electrons from the writing gun result in secondary emission from the screen greater than the primary, so that whenever the writing beam hits the storage mesh there is left a positive charge pattern. This permits the flood electrons to pass through and strike the phosphor.

The writing beam thus acts by producing a 'picture' on the storage mesh in the form of a charge pattern, and the flood beam thereafter continuously transfers this 'picture' to the phosphor where it produces a visible picture. The storage is effective for some 10–15 minutes, but can at any time be erased by applying a positive pulse to the storage mesh.

## Telstar

On 25th August a measurement was made of the time difference between the reference clocks of the U.S. Naval Observatory and the Royal Greenwich Observatory. They had previously been compared with a limiting accuracy of 1-2 msec, all that is possible with conventional radio time signals transmitted by routes depending on ionospheric reflections.

By using Telstar it was possible to reduce the limit to 10-12 μsec. It is now known that the clocks differ by 1·98 msec.

## U.H.F. Television

The B.B.C., in co-operation with the I.T.A., the Post Office and the Radio Industry and Trade, is carrying out a new series of field trials in the u.h.f. band from the Crystal Palace station. Initially a vision carrier only will be radiated on Channel 44 in Band V but it is expected that by the end of September test patterns will be introduced and later moving pictures. The transmissions are on Mondays to Fridays at 10.30 a.m. to 5 p.m. and 8-9.30 p.m.

Early in 1963 transmissions will also be made on Channel 34. The effective radiated power is about 160 kW. About mid-1963 the power will be raised to 500 kW and further tests carried out on a single channel, one of the four u.h.f. channels allocated to London under the Stockholm plan. This should give a range of some 30 miles apart from pockets of low field strength. One object of the trials is to establish the number and size of such pockets so that adequate plans for filling them can be made prior to the start of regular transmissions early in 1964.

## I.E.E.

There will be a three-day Symposium on Electronic Equipment Reliability organized by the Institution of Electrical Engineers on 24th-26th October. It will include a presentation of American views on system reliability.

A conference on the Design and Use of Microwave Valves is being organized by the Electronics Division of the I.E.E. and will be held during September 1963.

## S.I.M.A. at I.S.A.

With the co-operation of the Board of Trade, the Scientific Instrument Manufacturers' Association of Great Britain Ltd. is staging a group exhibit at the Instrument-Automation Conference and Exhibition in New York. Ten S.I.M.A. members are taking part and will show apparatus ranging from process control instrumentation to measuring equipment for determining the skidding qualities of roads.

## New Computer

The Elliott-Automation 900 Series Mobile Digital Electronic Computers, announced at the Farnborough Air Show, are claimed to be the fastest of their size. Calculations can be carried out at a rate of 50,000 a second yet the computer weighs only 100 lb and occupies 3 cu ft.

**For further information circle 45 on Service Card**

## Improved Antimony

Johnson Matthey are now producing high-purity antimony with a total metallic impurity content not exceeding 1 part per million as determined by spectrographic analysis. This new grade supplements the older ones with impurity contents of 200 and 5 parts per million.

**For further information circle 46 on Service Card**

# Correspondence

## Small-Scale Refrigeration

Sir,—The use of thermoelectricity (Peltier effect) for small-scale refrigeration has been known for some years and often demonstrated, typically by the production of a single ice cube. Its use for cooling miniaturized electronic equipment has been suggested and it is on record that it has been employed to cool a vidicon camera tube utilized in the high ambient temperature of a steel mill.

All the applications of which I have heard are in some way to electronic apparatus. It seems to me that there must be many more outside the electronics field but that the possibilities of thermoelectricity are not well enough known there.

I suggest, therefore, that you would be doing a service if you could make it more widely known that thermoelectricity is a very practical proposition for cooling where the heat transference involved is small.

*London, W.C.* W. J. Crier.

Sir,—In reply to your correspondent's interesting letter on thermoelectric cooling the following comments on our experience in this field will no doubt be of interest.

My company has been associated with the development, manufacture and application of thermoelectric cooling devices for a number of years and we were in fact, the first United Kingdom company to introduce them to the market.

In a comparatively short time we have given assistance in the application of these devices to a considerable number of companies in widely differing industries. Unfortunately, many of the most interesting and novel applications are confidential to our customers, each of whom is developing an entirely new piece of equipment based on the use of a thermoelectric device—equipment that would not have been practical with conventional cooling techniques.

Although it is true to say there has been a considerable interest shown in these devices for forward-thinking electronic engineers, there has also been a considerable interest shown by the medical, process control and chemical industries in particular. We have, in fact, developed apparatus which is now in use in these industries.

It is important to remember that these new devices are not only finding application where conventional cooling techniques are used, but also in many new applications where a reduction and control of temperature is advantageous which hitherto were beyond the scope of conventional cooling techniques. The modern thermoelectric cooling unit makes a phenomena of academic interest an accomplished technique for exploitation by the modern engineer.

T. D. Cockhill.

*Salford Electrical Instruments Ltd., Salford, Lancs.*

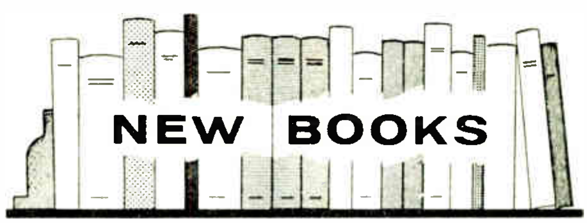
## Electronics Servicing

Sir,—As a regular reader of *Electronic Technology* since the early days of E.W. and W.E., I would congratulate the Iliffe directors for their wisdom in the extended coverage and re-naming of this excellent journal. For about 40 years it has presented a yardstick by which other technical journals in this field were judged. However, the ever-expanding interest and applications of electronics to fields outside that of communications left a gap in the literature which *Industrial Electronics* is now to fill.

The word 'electronics' is most difficult to define and in discussing the training of students with their parents I suggest that it covers every possible application of thermionic valves and semiconductors with the exception of domestic entertainment equipment. Already the applications of electronics to industry has created a great shortage of qualified electronics engineers and in particular service engineers. To help the industry in this direction the City and Guilds of London Institute introduced a new examination syllabus a year ago which provides a recognized qualification in electronics servicing. This department offers a course for electronics servicing which covers five years of day release or evening study and approximately 40% of the time is devoted to laboratory and practical work. The intermediate certificate is taken at the end of the third year and the final certificate at the end of the fifth year. Already a number of qualified radio and television servicing engineers have started training for this new qualification which offers a far wider scope than the more restricted field of servicing domestic equipment.

J. C. G. Gilbert.

*Department of Electronics and Telecommunications, The Northern Polytechnic, London, N.7.*




### Automatic Control Systems

By Benjamin C. Kuo. Pp. 504 + xii. Prentice-Hall International Inc., 28 Welbeck Street, London, W.1. Price 84s.

This book is of American origin and much of the material in it has been used in servo-mechanism courses at the University of Illinois. After an introductory chapter the author really starts work with a lengthy chapter on equations and models of linear systems. Electrical systems are first dealt with and, as examples, the mesh and nodal differential equations are given for a three-mesh network. The reader is, reasonably enough, assumed to be familiar with Kirchhoff's laws and to know how to write the basic equations.

However, the author immediately proceeds to generalize with a compact notation which is inadequately explained if the reader has not previously met it. A further couple of pages takes one into the Laplace transform and the use of determinants. There is no explanation of these here and the reader is obviously expected to be quite familiar with them. If he is not, much of what follows will be unintelligible. Mechanical systems, including gear trains, are treated and the author then turns to the transfer function and impulse response of linear systems. Block diagrams and signal-flow graphs are then considered.

Chapter 3 is on feedback and then the components of feedback control systems (potentiometers, synchros, tachometers, modulators, etc.) are discussed. The usual techniques of analysis are dealt with, in particular frequency-response and root-locus methods. These are both very fully treated.

The final chapters deal with sampled data systems and non-linear systems, and the book concludes with an appendix on the Laplace transform.

The book deals very thoroughly with the theory of automatic control, and it is only in places that the mathematical difficulties brought about by excessive generalization arise. For much of the book little more than an elementary knowledge of Laplace transforms is necessary. The whole book, however, cannot be understood without a considerable mathematical knowledge, and it is very far indeed from being a book for the beginner.

**Basic Electronic Circuits, Part 1**

Pp. 118 + iii. The Technical Press Ltd., 112 Westbourne Grove, London, W.2. Price 18s.

This is a basic-training manual 'developed by a special Electronics Training Investigation Team of the Royal Electrical & Mechanical Engineers working in conjunction with Technical Training Command of the Royal Air Force and Decca Radar Limited'. It is intended to supplement preceding manuals, 'Basic Electronics' and 'Basic Radar', and is in three parts.

The present volume is Part 1, and its first 42 pages are substantially recapitulatory material, 'confirming and building upon the basic theoretical knowledge which the reader will have gained from studying a preceding series of manuals'. The rest of Part 1 comprises 'An Illustrated Dictionary of Basic Electronic Circuits'. In this there are five sections:—Introduction, Amplitude-shaping circuits, Rectangular pulse generators, Pulse-lengthening circuits, and Pulse-shortening circuits.

Under Amplitude-shaping, for example, the principles of producing a square wave from a sine wave by limiting and the meaning of clamping are discussed in two pages. Series and shunt diode limiters are then described followed by triode, pentode, cathode-follower and transistor circuits; diode clamping circuits are then treated. All this is done in 20 pages, and well done. The writing is factual, simple and accurate. There is hardly any mathematics. There is a wealth of illustration.

The book is a very unusual one but we think that for its intended purpose it is a very good one.

**Télécommande et Télémesure Radio**

By JEAN MARCUS. Pp. 280. Editions Eyrolles, 61 boulevard Saint-Germain, Paris Ve. Price NF 49.45.

This book is essentially concerned with remote control of and remote measurements from air and space craft of one kind or another, ranging from ballistic missiles and guided craft to rocket launched space vehicles. There is an initial discussion of the various kinds of modulation in which the various characteristics of the different kinds are discussed and typical circuits are given. There is then a chapter on information theory and coding, followed by one on limitations. This is largely concerned with noise and interference, but goes on to deal with vibration, shock, acceleration, temperature, etc., and also includes distortion.

Fields, propagation and aerials are then covered and followed by a chapter on multiplexing. The final chapters deal with vehicle guidance by remote control and with telemetry. An appendix lists telemetry standards.

The more elementary forms of mathematics are freely used, but there is little of difficulty. The book should be a useful one to the newcomer to the subject, as long as he has an adequate knowledge of French.

**Dictionary of Physics and Allied Science, Vol. 2 English-German**

Edited by RALPH IDLIN. Pp. 634. Peter Owen Ltd., 50 Old Brompton Road, London, S.W.7. Price 75s.

This is a comprehensive dictionary which should be of considerable assistance to translators from English into German. A feature is the indication which is given of the proper choice of German words in cases where there are several possible translations.

## Manufacturers' Literature

**Daystrom 'Squaretrim' Sub-miniature Trimming Potentiometers.** A single-sheet publication which gives details of the 210 Series of ⅜in. square trimming potentiometers which are produced by:

*Daystrom Inc., Archbald, Pennsylvania, U.S.A.*

**For further information circle 47 on Service Card**

**A Primer for Computing Resolvers.** This 16-page brochure discusses the characteristics of resolvers and a number of methods used to specify them.

*Theta Instrument Corporation, 520 Victor Street, Saddle Brook, New Jersey, U.S.A.*

**For further information circle 48 on Service Card**

**Precision Reinforced Mouldings.** In this 12-page publication many illustrations are given of the application of glass-reinforced plastics.

*Precision Reinforced Mouldings Ltd., Tolpits Lane, Watford, Herts.*

**For further information circle 49 on Service Card**

**Printed Circuits and Components.** This 27-page booklet for the designer of printed circuits has been produced by:

*Tectonic Industrial Printers Ltd., Cirtec Works, Oxford Road, Wokingham, Berks.*

**For further information circle 50 on Service Card**

**Inlaid Contact Bi-Metal.** A revised data sheet on inlaid contact bi-metal by:

*Johnson Matthey & Co. Ltd., 73-83 Hatton Garden, London, E.C.1.*

**For further information circle 51 on Service Card**

**R.C.A. Semiconductor Product Guide.** A 12-page publication by:

*Radio Corporation of America, Clark, N.J., U.S.A.*

**For further information circle 52 on Service Card**

**Contactors and Starters; Control Gear Accessories.** An 8-page brochure produced by:

*Switchgear Division of G.E.C. (Engineering) Ltd., Birmingham, 6.*

**For further information circle 53 on Service Card**

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| Offset Voltage $V_{EC}(I_B = -200\ \mu a, I_E = 0)$ | 1.5 mv max. |
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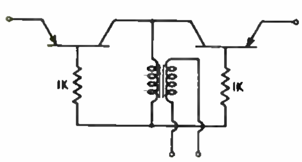
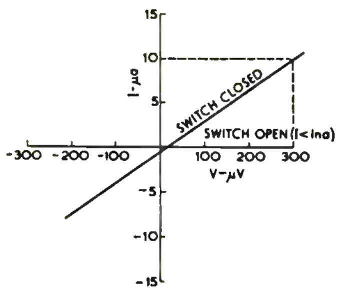



### T2363: I-V CHARACTERISTIC
(in above circuit)

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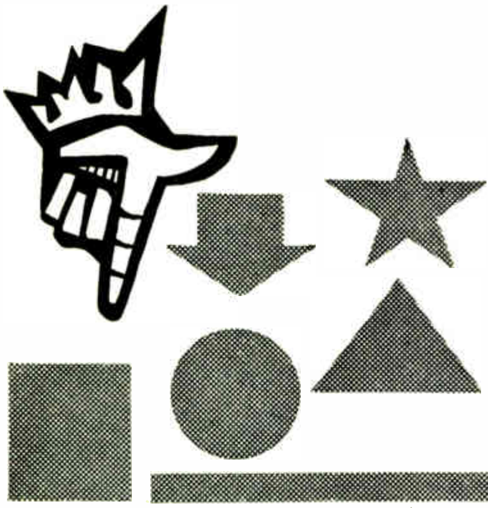

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| $V_{CE}$ (SAT) ($I_C$ = —50 ma, $I_B$ = —2 ma) | | | 0.30 v max | 0.55 v max | 0.25 v max | 0.45 v max |
| $V_{BE}$ ($I_C$ = —10 ma, $I_B$ = —0.4 ma) | 0.27 min 0.36 max | 0.34 min 0.50 max | 0.27 min 0.36 max | 0.34 min 0.50 max | 0.27 min 0.36 max | 0.34 min 0.45 max |
| $V_{BE}$ ($I_C$ = —50 ma, $I_B$ = —2 ma) | | | 0.38 min 0.48 max | 0.45 min 0.75 max | 0.38 min 0.48 max | 0.45 min 0.70 max |
| $C_{ob}$ ($V_{CB}$ = —5 v, $I_E$ = 0, f = 4 mc) | 4.0 pf max | 7.5 pf max | 4.0 pf max | 6.0 pf max | 4.0 pf max | 6.0 pf max |
| $f_T$ ($V_{CE}$ = —7v, $I_C$ = —10 ma) | 150 mc min | Same @—5 $V_{CE}$ | 200 mc min | 150 mc min @—5 $V_{CE}$ | 250 mc min | 150 mc min @—5 $V_{CE}$ |
| $t_{on}$ (max) | 75 nsec | 100 nsec | 75 nsec | Same | 75 nsec | Same |
| $t_s$ (max) | 140 nsec | 200 nsec | 120 nsec | Same | 100 nsec | Same |
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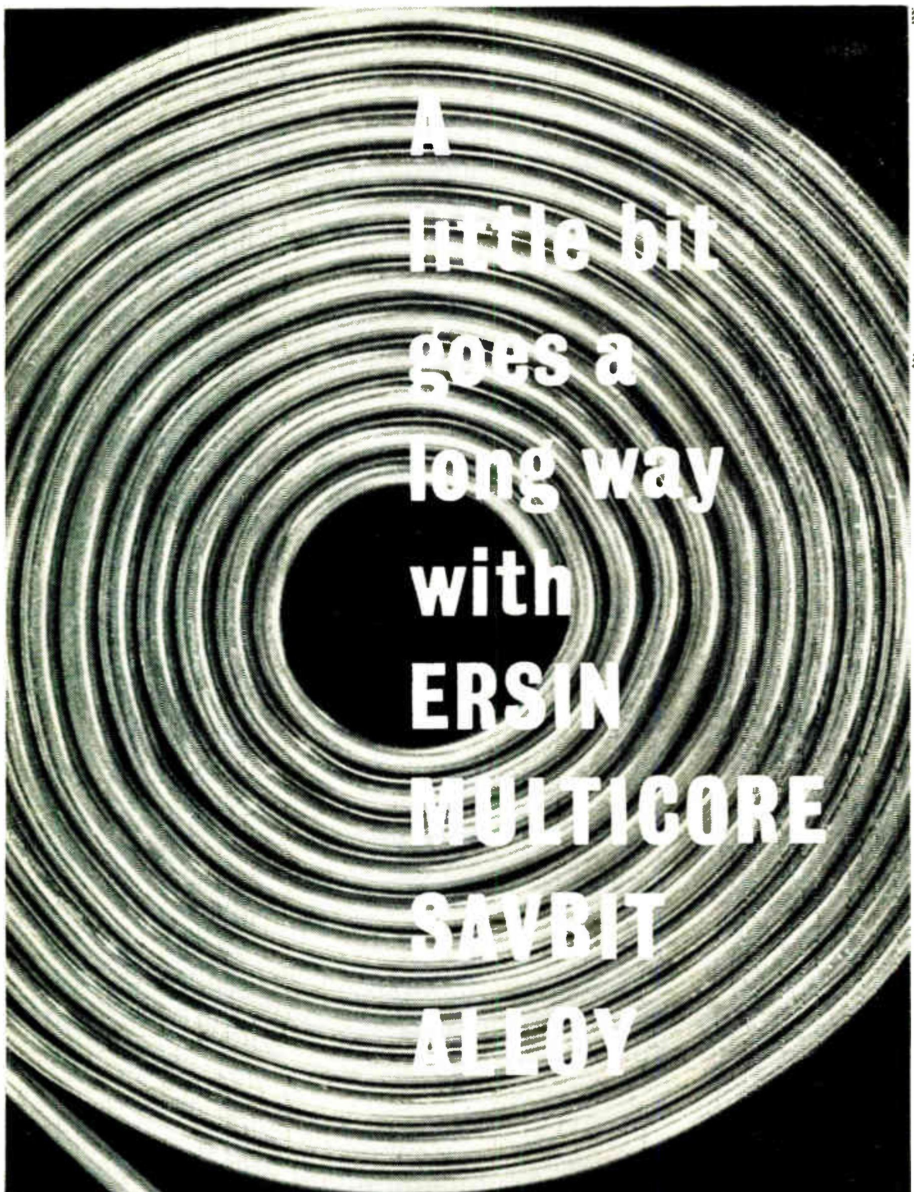


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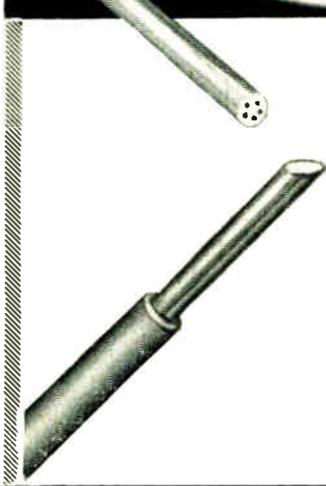
| 14 | 60.8 |
| 16 | 96.2 |
| 18 | 170 |
| 19 | 244 |
| 20 | 307 |
| 22 | 508 |



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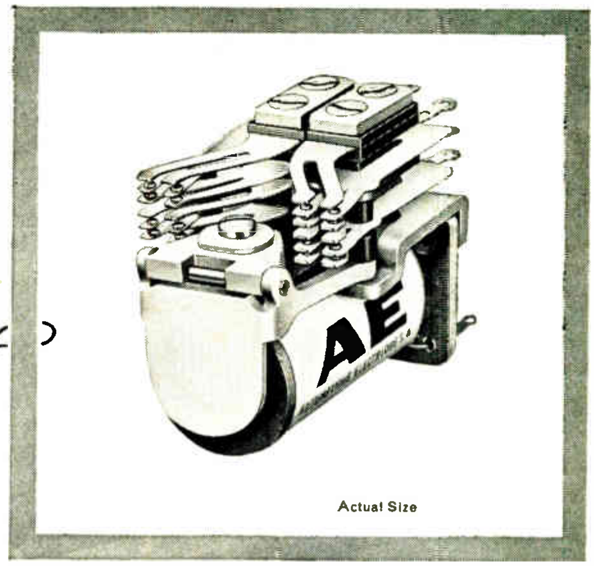

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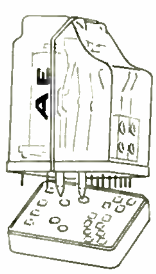

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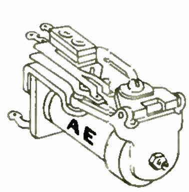

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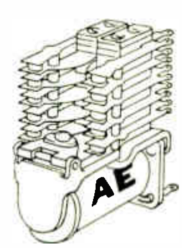
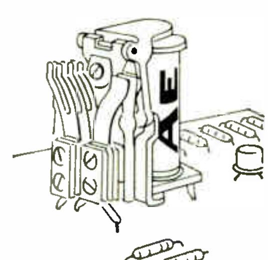


With power contacts



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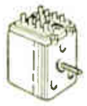



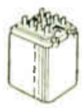




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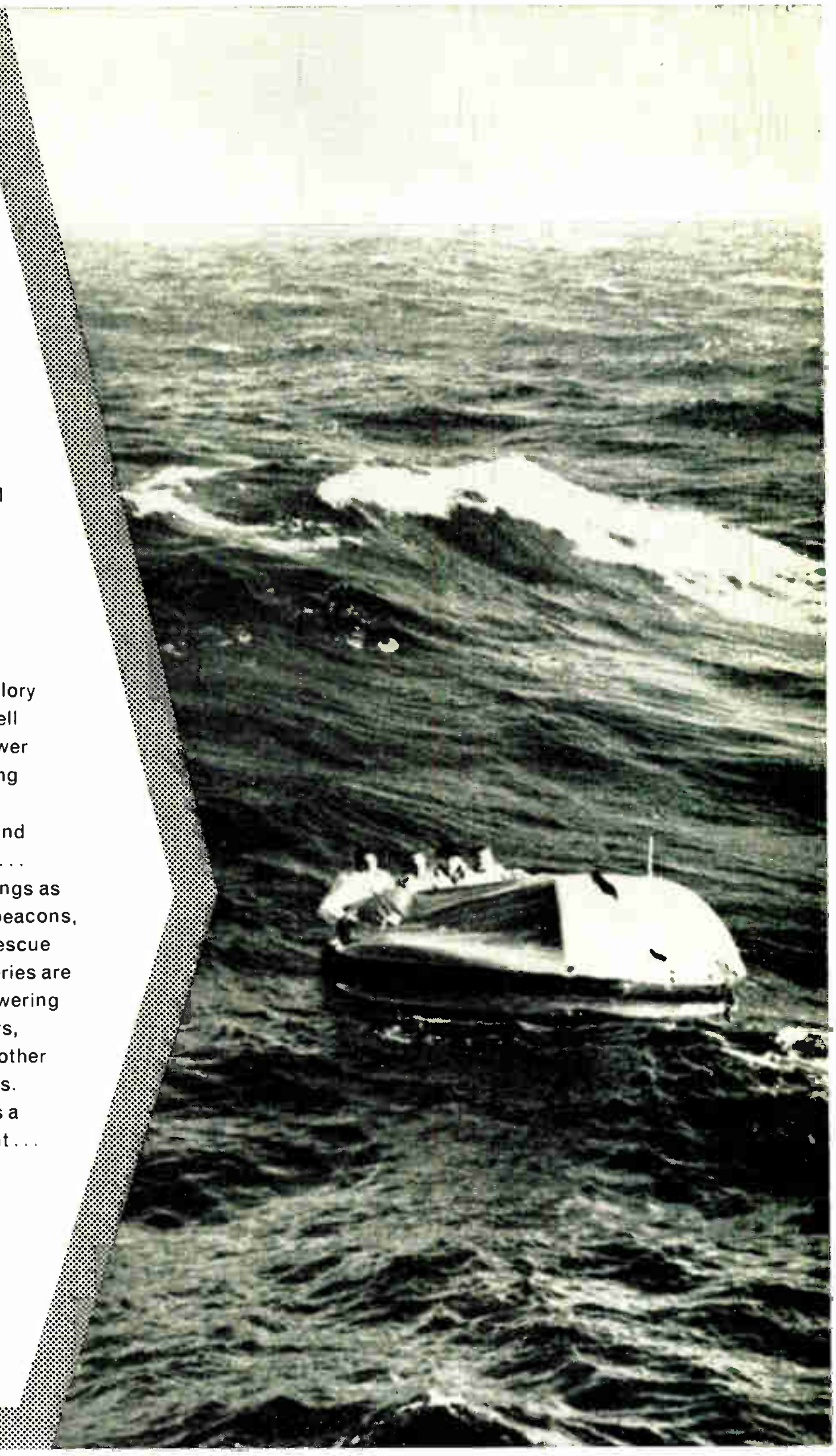

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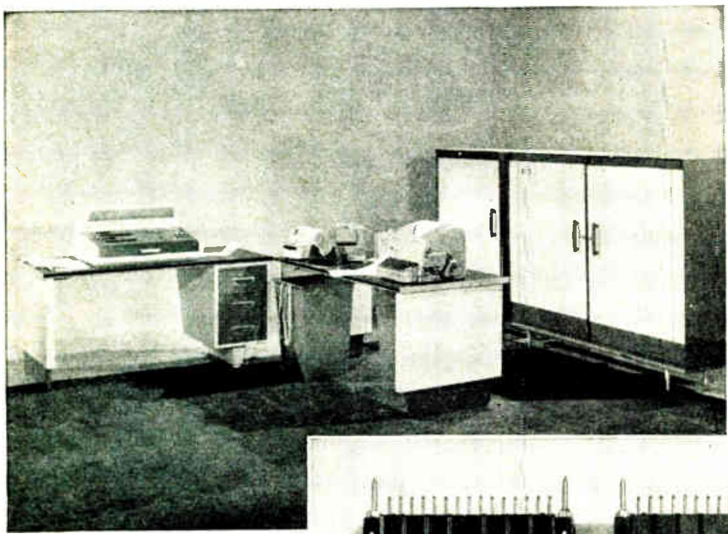

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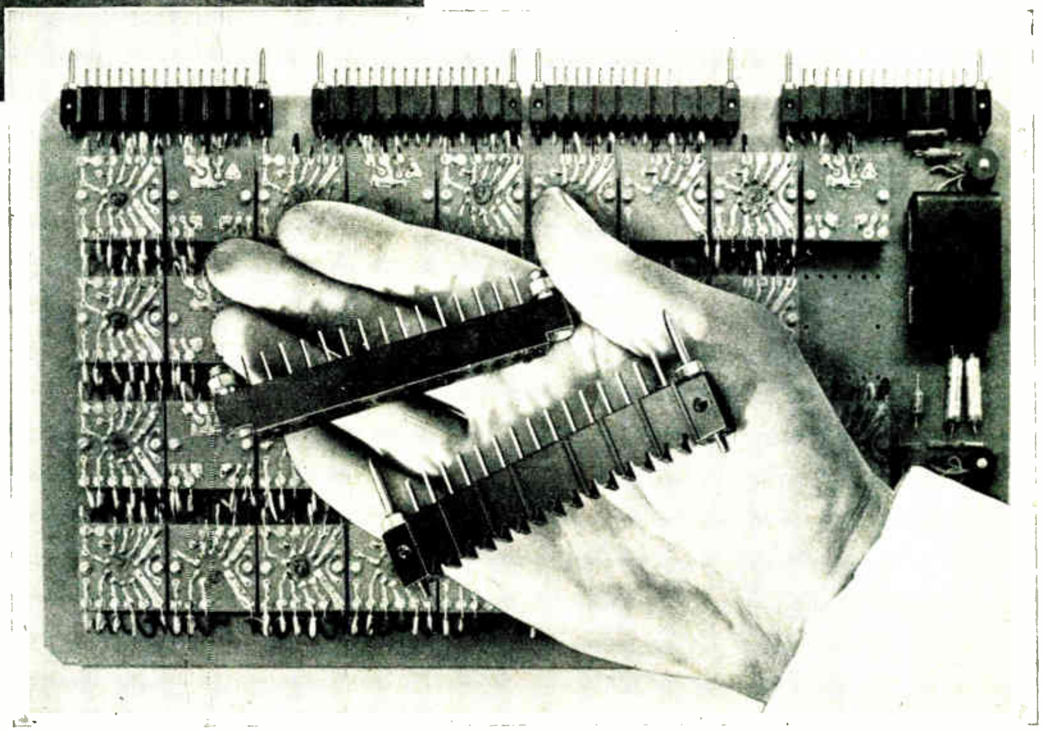

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*See front cover of this journal.*

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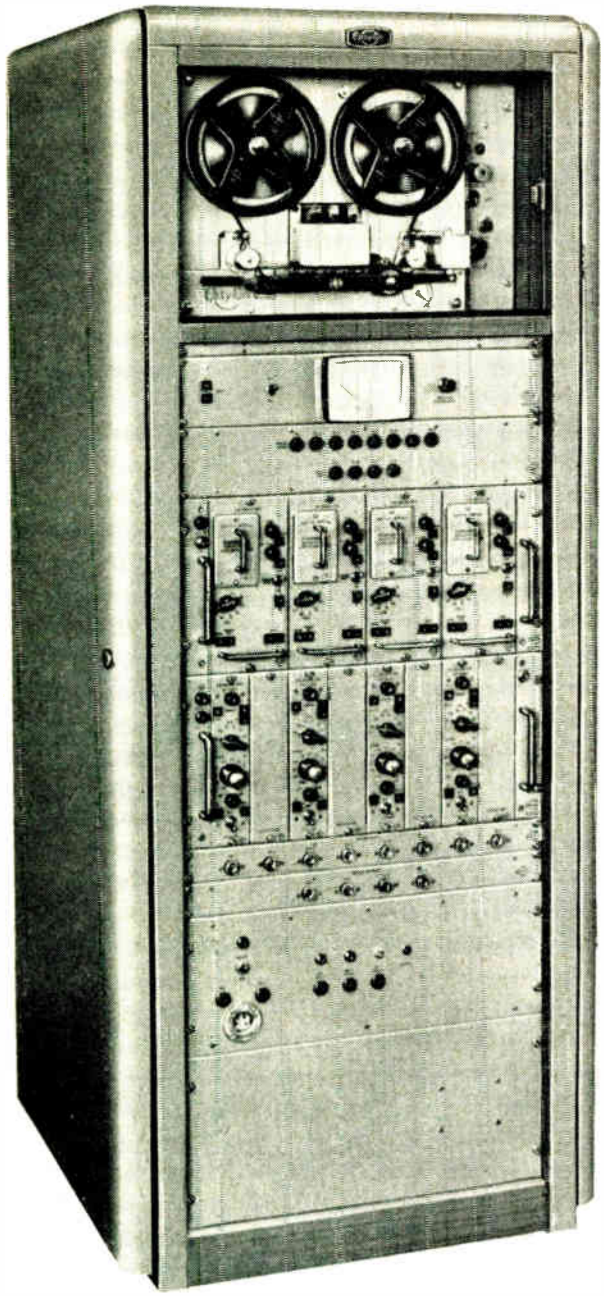

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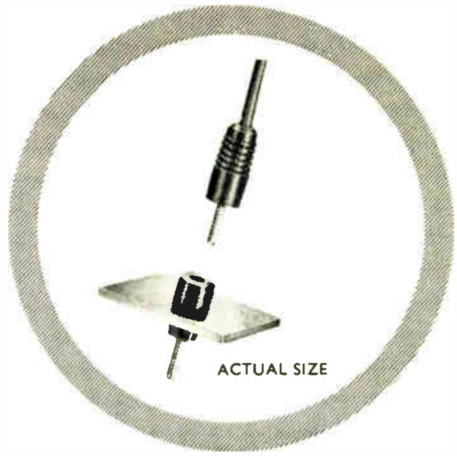


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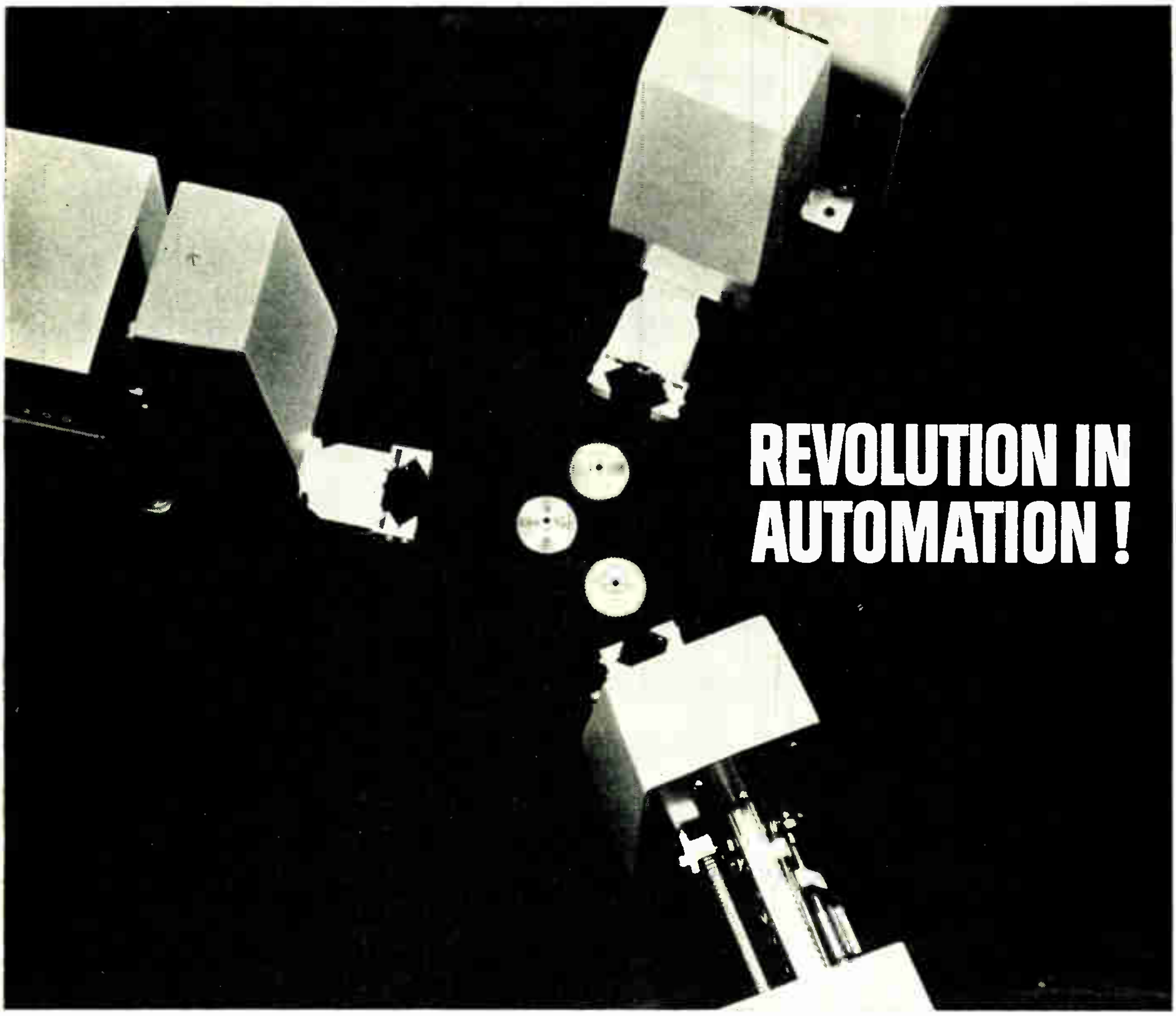


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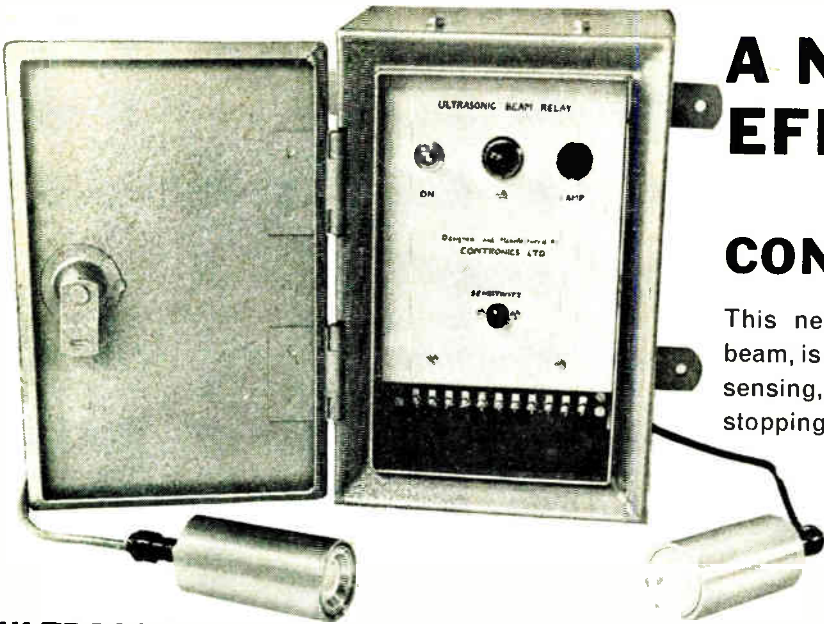


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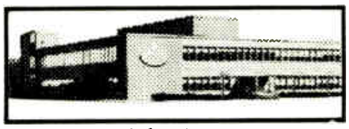

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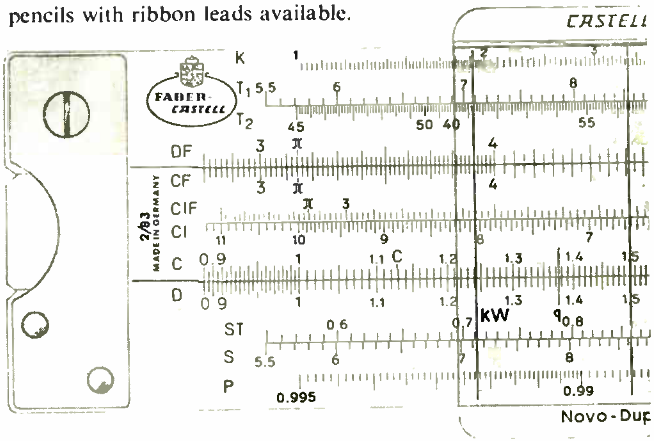


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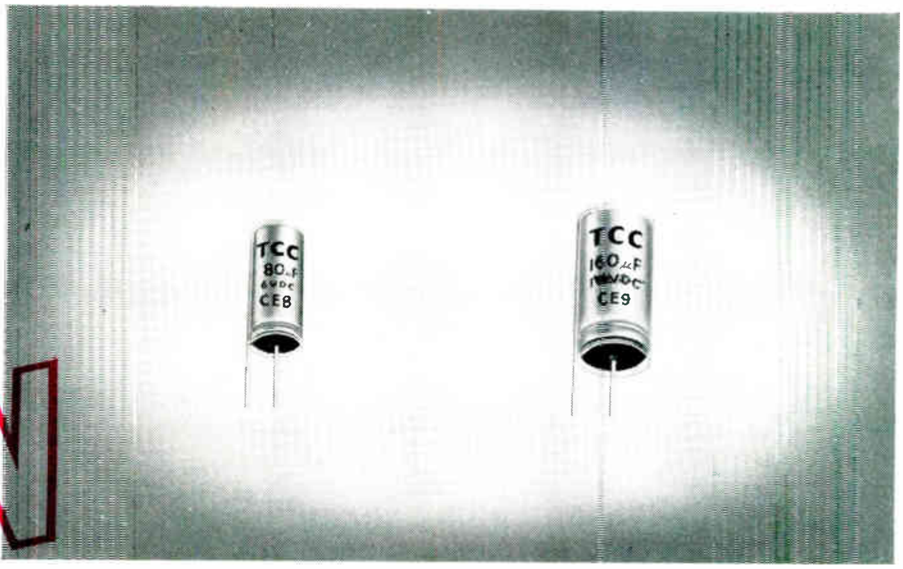


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|---|---|---|---|---|---|---|---|---|---|
| | D | L | C | 3V. | 6V. | 10V. | 15V. | 25V. | 50V. |
| CE.8 | $\frac{1}{4}$ | $\frac{3}{4}$ | 0·14 | 100 | 80 | 60 | 40 | 25 | 8 |
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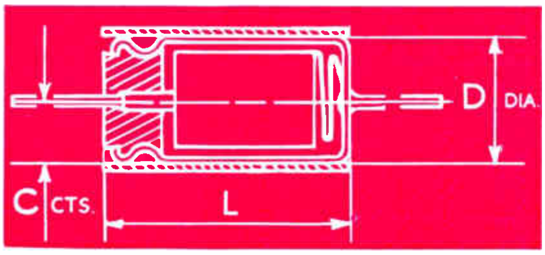


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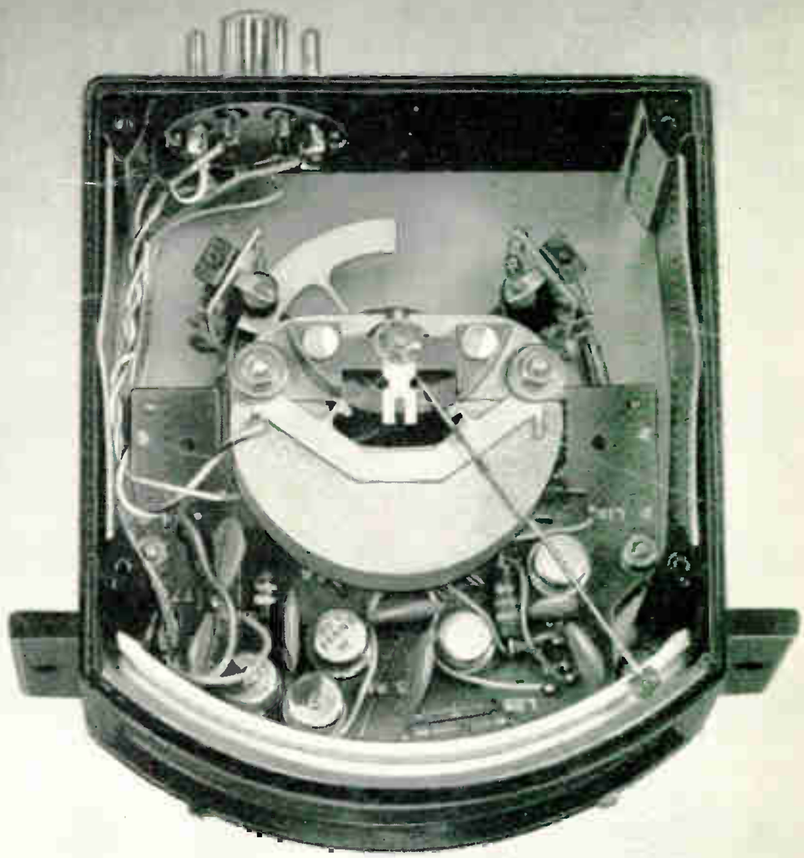


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