DECEMBER 1960

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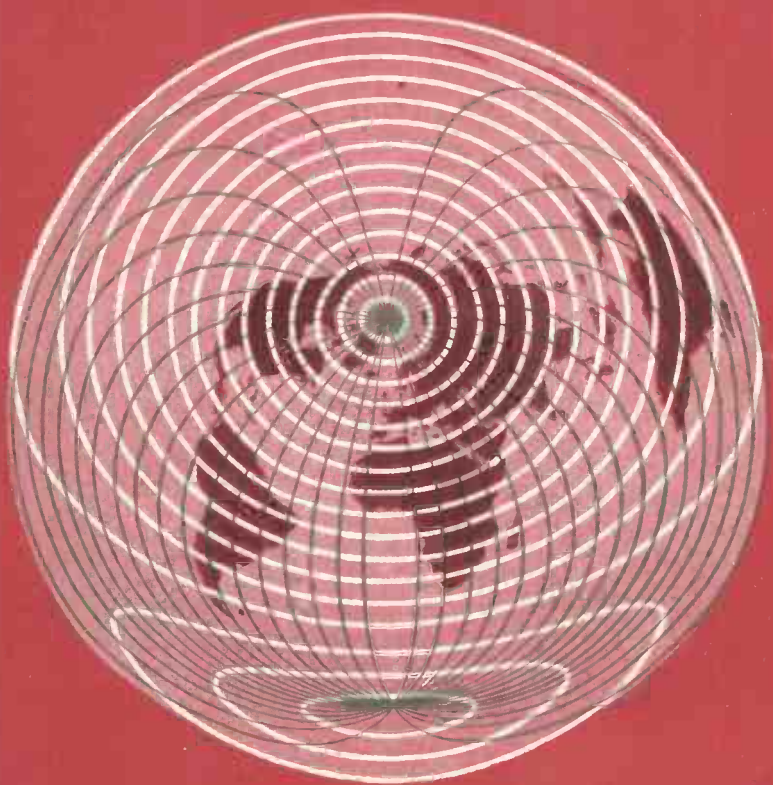
Wireless World

ELECTRONICS
Radio · Television



FIFTIETH YEAR OF PUBLICATION

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Heater voltage (volts)	V_h	4·0 - 6·3
Heater current (amps)	I_h	0·72-0·3
Anode voltage, rating (kV)	V_a (max)	10·0
Anode voltage, typical operation (kV)	V_a	9·5

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Wireless World

ELECTRONICS, RADIO, TELEVISION

DECEMBER 1960

VOLUME 66 No 12.

PRICE: TWO SHILLINGS

FIFTIETH YEAR OF PUBLICATION

Offices: Dorset House, Stamford Street, London, S.E.1

Please address to Editor, Advertisement Manager, or Publisher, as appropriate

PUBLISHED MONTHLY (4th Monday of preceding month) by ILIFFE & SONS, LTD., Dorset House, Stamford Street, London, S.E.1. *Telephone:* Waterloo 3333 (65 lines). *Telegrams:* " Ethaworld, Sedist, London." *Annual Subscriptions. Home and Overseas,* £1 15s. 0d. *Canada and U.S.A.,* $5.00. Second-class mail privileges authorised at New York, N.Y. BRANCH OFFICES: *BIRMINGHAM:* King Edward House, New Street, 2. *Telephone:* Midland 7191. *COVENTRY:* 8-10, Corporation Street. *Telephone:* Coventry 25210. *GLASGOW:* 62, Buchanan Street, C.1. *Telephone:* Central 1265-6. *MANCHESTER:* 260, Deansgate, 3. *Telephone:* Blackfriars 4412. NEW YORK OFFICE: *U.S.A.:* 111, Broadway, 6. *Telephone:* Digby 9-1197.

DECEMBER 1960
Vol. 66 No. 12

Wireless World

Radiation at Very Low Frequencies

IN the present state of the art there are often times when the study and practice of radio may seem to be a hard grind. "Under the sun there's nothing new" and work consists of mastering known principles and taking advantage of improved materials to refine existing designs. But our subject is never dull for long. The field is wide, the labourers are many and new finds in old workings are constantly turning up to fire the imagination and shift the centres of interest. Hertz worked with centimetre waves, and electromagnetic waves at frequencies which would be audible if air were the propagating medium were widely used in the early days.

From these extremes of frequency interest tended later to converge to the intermediate values which gave greater bandwidth and traffic-handling capacity, lower capital cost for transmitters and greater running economy. In recent years the interest, as far as frequencies are concerned, has again become divergent; to centimetric waves for narrower beams and higher discrimination in radar, and to very long waves for special navigation and communication systems and for geophysical research.

In passing, it is of interest to recall the criticism which was levelled at the Post Office for continuing in their policy of building a high-power long-wave station at Rugby, when the new short-wave beam stations were showing every promise of making it obsolete. A similar situation is now arising between the fact of the Commonwealth telecommunications project and the promise of satellite communications.

Although the bulk of the world's communication traffic took to the new short-wave bypass, we have reason to be grateful, now more than ever before, that the Post Office, and authorities in other countries, did not allow the old low-frequency roads to fall into disrepair. The services of Rugby GBR (16kc/s) and Criggion GBZ (19.6kc/s) are much in demand all over the world not only for communication but for time and frequency comparison and, because of their wide dissemination and high stability, for navigational purposes. New stations, working on similar frequencies with powers of 1MW, have been built in the U.S. for communication with submarines.

At "extremely low" frequencies[1] there is world-wide interest and much international co-operation in the investigation of electromagnetic phenomena of terrestrial and extra-terrestrial origin. Lightning flashes produce transients with e.l.f. components of considerable magnitude, and correlation has been established with perturbations of the geomagnetic field. But by far the most interesting development in the e.l.f. and v.l.f. ranges has, in our opinion, been the investigation of "whistlers," which can be heard under favourable conditions and in high latitudes by connecting an aerial directly to the input of an audio amplifier. These have been shown to have their origin in lightning flashes and to owe their peculiar sound to the different rates of propagation with frequency of the components of the original pulse waveform in following the lines of force of the earth's field through a dispersive medium. This gave the first intimation, later confirmed by rocket exploration, of the existence of belts of ionized particles extending to heights of many earth radii.

While much new knowledge has been collected by patient observation and analysis of natural phenomena, more rapid progress would be made if controlled impulses and burst of radiation at specific frequencies could be launched, particularly from the polar regions. But the resources of conventional radio engineering find themselves hard pressed in trying to emulate lightning as far as power and radiator dimensions are concerned. Many ingenious suggestions have been put forward, for example, that v.l.f. signals might be superimposed on the electricity grid system. Unfortunately, grid systems are seldom to be found where the scientists want them. An experiment, reported on page 614 of this issue, makes use of a 10,000 ft. aerial wire suspended from a helicopter in what must surely be the biggest mobile-marine transmitting station ever devised. Even so, the aerial is no longer than that used at the Marconi transatlantic receiving station at Towyn in the early 1920s.

To our way of thinking, the most ingenious suggestion put forward so far is that due to M. G. Morgan[2], of the Thayer School of Engineering, Dartmouth College, Hanover, New Hampshire, U.S.A. This is to use the whole of Deception Island in the South Shetland Islands as a slot aerial, using the surrounding sea as the ground plane conductor. The island is the rim of a submerged volcano and has one gap leading to an inner lagoon. An expedition of the Falkland Islands Dependencies Survey is now on its way with equipment to check that the rock formation is a good enough insulator and to measure the impedance of the "slot," which has a calculated resonant frequency of 5kc/s. If the answers are favourable it is hoped to try to energize the "aerial" at points opposite to the lagoon entrance by current entering the sea on each side of the saddle, and thus to launch waves upwards into space.

We wish every success to this enterprise, which has shown that the older arts of radio are still as capable of stirring the pulse as those of its younger offspring, electronics.

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[1] Designated as the range from 1c/s to 3kc/s at the January 1960 Conference on Propagation of E.L.F. Electromagnetic Waves, Boulder, Colorado, U.S.A., and reported in the National Bureau of Standards Technical News Bulletin, Vol. 44, No. 5, May 1960.

[2] *I.R.E. Trans. on Antennas and Propagation*, Sept. 1960.

Practical Aerial Measurements

By F. C. JUDD*

INVESTIGATING PERFORMANCE OF AERIALS BY MEANS OF SCALE MODELS

CALCULATING the radiating and/or pick-up properties of any aerial is a tedious process and does not take into account its environment once *in situ*. For this reason alone many engineers and organizations who specialize in aerials use scale models operated at very high frequencies for determining performance under working conditions. Practical experiments of this nature are fascinating to say the least, and may be carried out by anyone with a few simple items of equipment plus a little knowledge of basic principles of radiation.

The aerial "table" described in this article was constructed mainly for investigating the performance of aerials used for amateur radio transmitting and for live demonstrations during lectures.

For this article the reader is asked to assume that all reference to the performance of an aerial is in the radiating sense. The characteristics and performance of an aerial during reception are for all practical purposes reciprocal and identical. It is easier to think and talk in terms of radiation.

In general the object of the aerial designer is to produce standing waves on the radiating elements of an aerial so that radiation takes place in a known manner and where required. For example, resonance may be obtained with a quarter wavelength of wire if one end is on a theoretically infinite conducting sheet (e.g. copper) placed perpendicular to the wire. The reflection from the sheet then produces an image of the quarter-wave wire, as, say, a pencil standing on a mirror appears to be carried on into the mirror. The system resonates as freely as a half-wave length of wire but with halved radiation resistance.

The diagram of Fig. 1 shows how reflection from the earth takes place and how the angle of reflection is determined by either the height or the length of the aerial above ground. As the height or length is increased the relative phase angle between the direct and reflected wave will vary, thus modifying the strength of radiation in different directions.

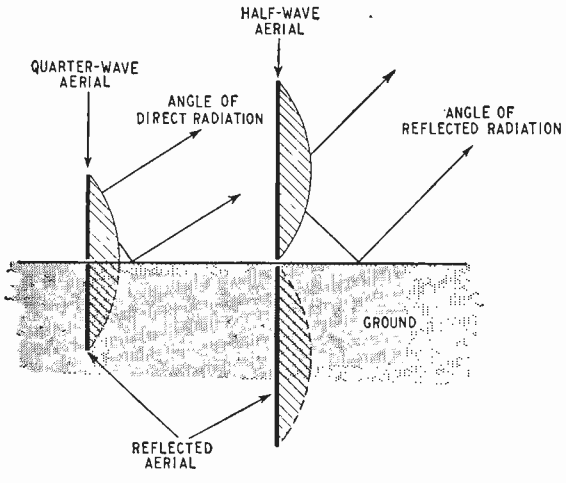


Fig. 1. Direct and reflected radiation from aerials adjacent to earth.

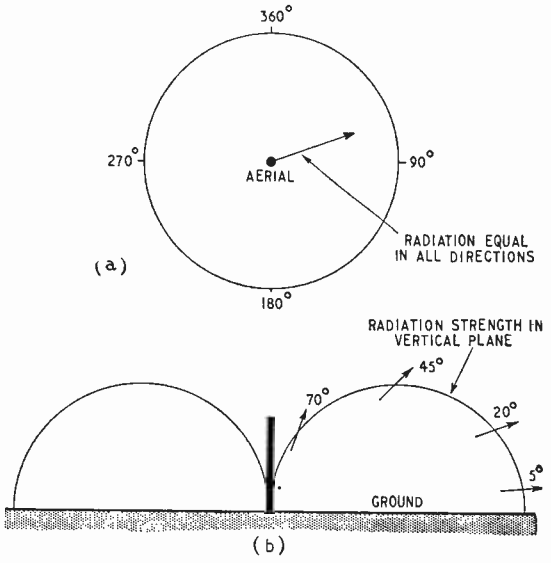


Fig. 2. Radiation field from vertical aerial; (a) in horizontal plane, (b) in vertical plane.

Radiation from any aerial system is determined by resonant length, or by the physical assembly of a number of radiating and/or reflecting and directing elements (beam aerials). For example, the radiation from a single vertical $\lambda/4$ radiating element is uniform for all directions around the aerial (horizontal plane). In the vertical plane the field strength varies as the angle from the ground increases, being maximum at ground level and zero in the true vertical direction as shown in Fig. 2.

In free space, clear of any conducting or semi-conducting obstacles, an aerial generally behaves according to accepted theories, but in the presence of other conductors and earth, the true radiation pattern may become very much modified. Since the height of an aerial above ground will never be very great (compared with an imaginery position in free space) the earth and its conductivity always play a great part in forming the actual radiation pattern. The term "earth" or "ground" applies also to aerials on aircraft since the body of an aircraft may be regarded as "earth" and usually has considerable effect on radiation.

The Theory of Similar Aerials.—The difficulties involved in plotting, other than the ground radiation

* Amateur Radio Station G2BCX

field of aerials operating in the lower portion of the radio frequency spectrum, make it almost impracticable to attack the problem. It becomes necessary, therefore, to devise some other system, other than calculation, for investigating true radiation patterns. The use of scale models is not an entirely new idea, for the method was used before the war by the B.B.C. and others, although the scale reduction of the models was limited owing to lack of suitable sources of r.f. power for very high frequencies[1].

From a practical point of view a half-wavelength aerial resonant at say 10 centimetres (3,000Mc/s) would behave in the same way as an aerial of similar type operating at 10 metres (30Mc/s) or even at 100 metres (3Mc/s), provided all other conditions were maintained, i.e. height above ground, conductivity of ground, dielectric constants and/or conductivity of materials used for the manufacture of the aerial and the effects of surrounding objects. Most of these can be simulated in scale models and the results of small differences ignored, although at certain very high frequencies the construction of an accurate model does become more difficult.

The problem of suitable methods of feeding the aerial also arises and at frequencies above about 200Mc/s the radiation field, particularly from balanced aerials such as the dipole, may become asymmetrical owing to inaccurate matching of aerial to feed system. (Some asymmetry may be noticed in the dipole pattern of Fig. 9.)

The method does, however, provide a means of establishing the pattern of the radiation strength in both the vertical and horizontal planes, as well as the effect of surrounding buildings and similar structures. Measurement of gain in beam aerials may be carried out and the effect of physical modifications rapidly ascertained. Many commercial concerns use the scale model method for determining radiation patterns, etc., the U.S.A. Bureau of Standards for example have a "Model Antenna Testing Range"; many aircraft companies use scale model aerials in conjunction with model aircraft to the same scale[2, 3].

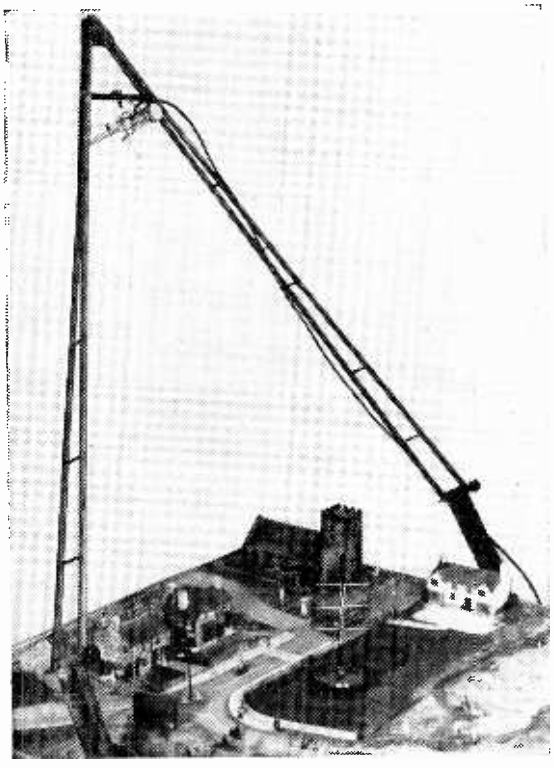


Fig. 3. The 3,000-Mc/s model aerial testing table (scale 4mm/ft) used by the author. The aerial shown in lower centre is a scaled-down 6-element, stacked array for a normal frequency of 30Mc/s.

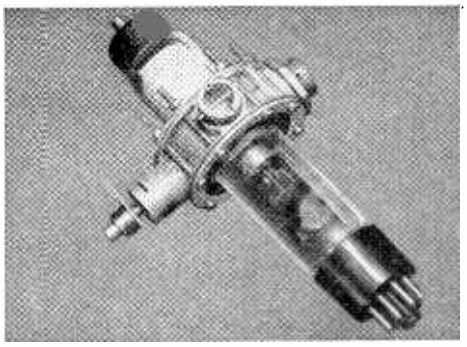


Fig. 4. Typical 3,000-Mc/s Klystron oscillator, the Type CV67.

Suitable Frequencies.—The writer's earliest experiments were carried out with an operating (model) frequency of 144Mc/s and many types of aerials commonly used for the radio amateur bands of 1.8, 3.5, 7 and 14Mc/s were scaled down for measurement of gain and radiation. More than 30 model aerials were constructed, most of the tests being carried out over normal earth. Attempts were later made to construct a "table" which could be used indoors but even at a frequency of 800Mc/s reflection from walls, etc., was found to be troublesome and imposed considerable restriction on accuracy.

A Practical 3,000-Mc/s Model Aerial Table.—To avoid inaccuracies due to unwanted reflection and to allow time for the complete formation of the electric field from a radiating aerial, the field strength meter and its aerial should be at least five wavelengths distant from a radiating aerial under test. The higher the frequency the shorter becomes the free space wavelength and at 3,000Mc/s it becomes possible to construct equipment suitable for indoor demonstration, as well as for reliable estimation of field patterns.

The aerial table shown in Fig. 3 was constructed in three sections to form a total area 4ft 6in square. Plywood, backed with thin aluminium sheet was used for this and forms an effective ground plane or artificial earth. The table contains a section of a typical residential area modelled at 4mm/ft and is constructed mainly from materials that simulate as near as possible those normally used for full-size structures.

Mounted directly under the centre of the table is a 3,000-Mc/s Klystron oscillator (CV67), complete with power supplies and modulator, which provides r.f. power for the model aerials, the r.f. output being taken to an aerial via a specially designed rotating coupling flush with the top of the table. The Klystron and its associated assembly can be turned through 360° by means of a slow-

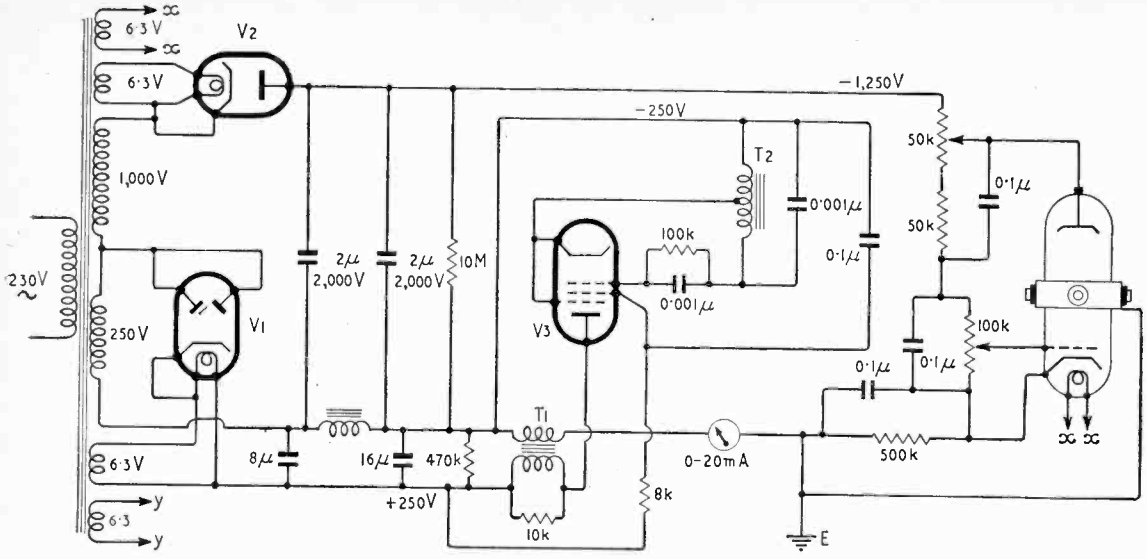


Fig. 5. Klystron oscillator, power supply and modulator used by the author. V1 = 250V rectifier; V2 = 1,250V rectifier; V3 = EF91; Klystron (see text); T1 = modulation transformer, ratio 1 to 1; T2 = tapped a.f. transformer.

motion drive and hand wheel located at the side of the table.

Klystron oscillators, such as the CV67 shown in the photograph of Fig. 4, may be obtained from Government surplus supply sources. Other Klystrons suitable for this work include the CV36 (2,850Mc/s), CV116 (3,540Mc/s), CV23 (3,300Mc/s) and the CV238 (3,050Mc/s). The latter two are low voltage types and require 250 volts between anode and cathode and 100 to 200 volts for grid bias and the target anode. The others operate with up to 1,500 volts on the target anode and take an average current of 5m/A. These Klystrons have fine and coarse tuning adjustment plugs fitted around the resonant cavity and provide an r.f. output of 100 to 150 milliwatts.

The Klystron oscillator and modulator circuit used by the writer is shown as Fig. 5. Component values may have to be modified slightly, although those given should be close enough to enable the circuit to function reasonably efficiently.

On either side of the table and on a line through the axis of the rotating coupling, two supports carry an inverted "V" frame. This is based on an arrangement used by the U.S.A. Bureau of Standards, which permits the field-strength meter and its associated receiving aerial, which are mounted at the apex of the frame, to move through an arc of 180°. This arc extends from ground level on one side of the aerial to ground level on the other.

The frame may be locked in any position so

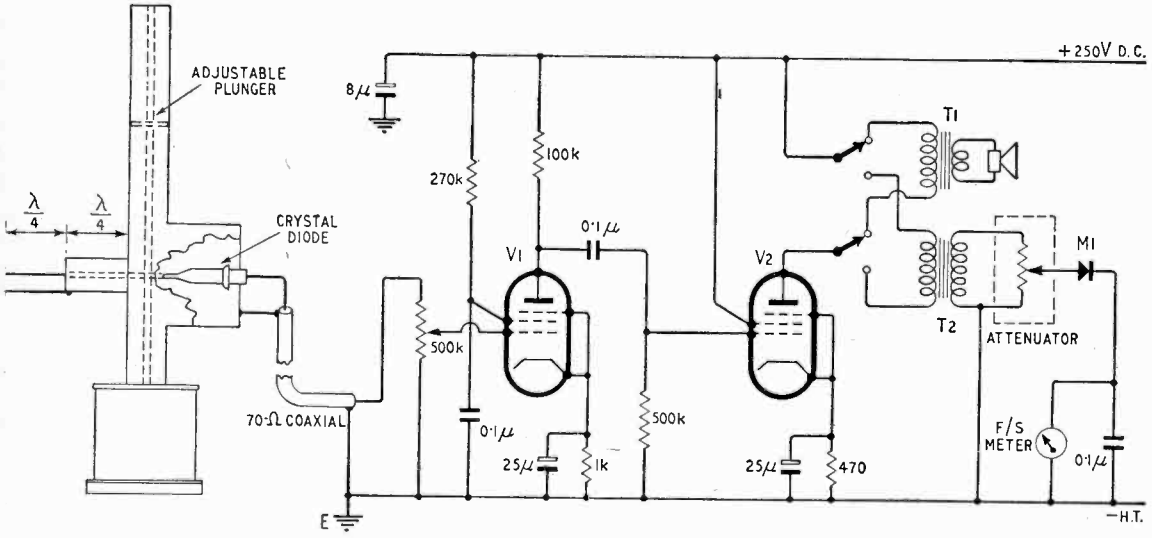


Fig. 6. Receiver and field-strength meter used for aerial measurements at 3,000Mc/s. V1 = EF91, V2 = EL91; T1 = loudspeaker transformer; T2 = 1 to 1 ratio a.f. transformer; M1 meter rectifier or diode.

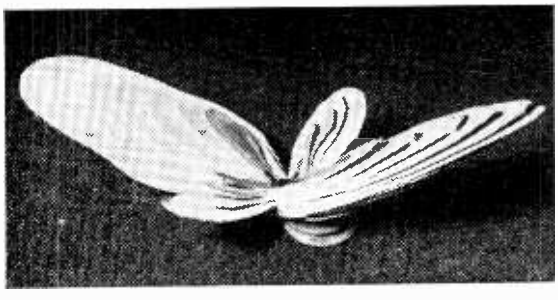
that a horizontal radiation pattern can be plotted for any vertical angle with respect to earth.

The Receiver and Field Strength Meter.—The 3,000-Mc/s receiver consists of a tunable resonant cavity and a crystal diode from which the demodulated signal is fed via an audio amplifier to a variable attenuator. Various surplus 3,000-Mc/s radar tuning units may be adapted for this purpose and used in conjunction with an amplifier circuit similar to that of Fig. 6. The audio signal level is indicated by a sensitive meter calibrated in 15 equal divisions, this being equivalent to the ruling of Chartwell Polar Co-ordinate paper, Sheet No. 4001. The attenuator is directly calibrated in decibels. The Klystron modulating signal is about 1,000c/s so that a loudspeaker may be connected in place of the meter for practical demonstration purposes.

As an alternative to the Klystron for a source of r.f. power there are many conventional valves that will oscillate at a 1,000Mc/s or more. If lower frequencies are used, however, the model aerials will be correspondingly larger but still suitable for open-air operations. Only a few milliwatts are needed to drive the aerials and ensure full-scale meter readings, so that radiation will be quickly absorbed and will not travel very far if experiments have to be made out of doors.

Plotting Radiation Patterns.—Clear surroundings are very necessary and the equipment should be carefully sited several wavelengths (at operating frequency) away from other conductors such as electrical wiring, metal window frames and pipes. Gain measurements may be made with respect to a "standard dipole," the radiated power from this being taken as a reference and regarded as 0dB. The importance of clear surroundings will be appreciated when attempts are made to simulate by means of models the conditions imposed by the presence of buildings and other structures. Two-dimensional "solid" patterns of a radiation field are more interesting than the conventional polar diagrams, especially for demonstration and from these a very clear conception of radiation directivity may be obtained. These two-dimensional shapes are produced by taking patterns from an aerial every few degrees in the vertical or horizontal plane, whichever is applicable, each pattern being drawn on thin cardboard, cut out and glued together in the correct order as shown by the example of Fig. 7. A selection of patterns taken from model aerials on the testing table described in this article are shown in Figs. 8, 9, 10 and 11. The model aerials are shown in the photograph of Fig. 12.

Fig 7. Solid radiation pattern of two vertical half-wave aerials spaced one wavelength apart and fed in phase.



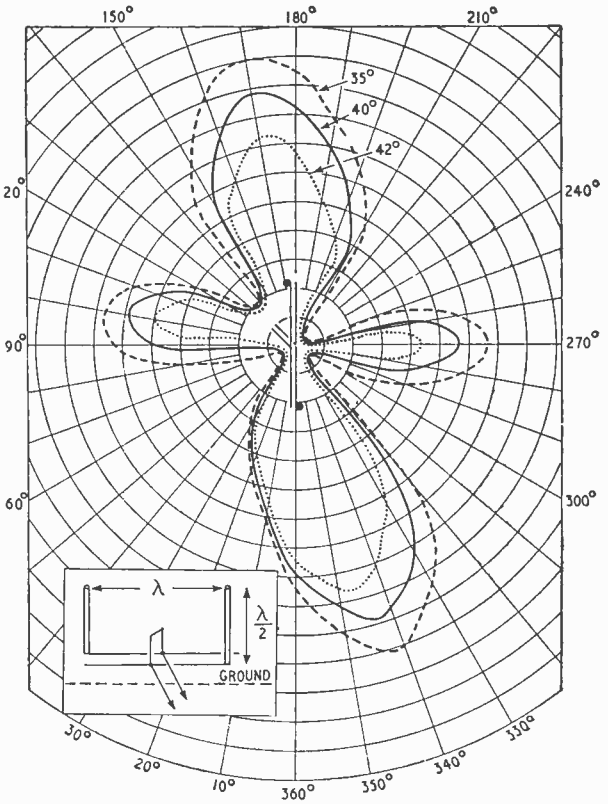


Fig. 8. Radiation patterns of two vertical half-wave aerials as described in Fig. 7 and measured at three different vertical angles.

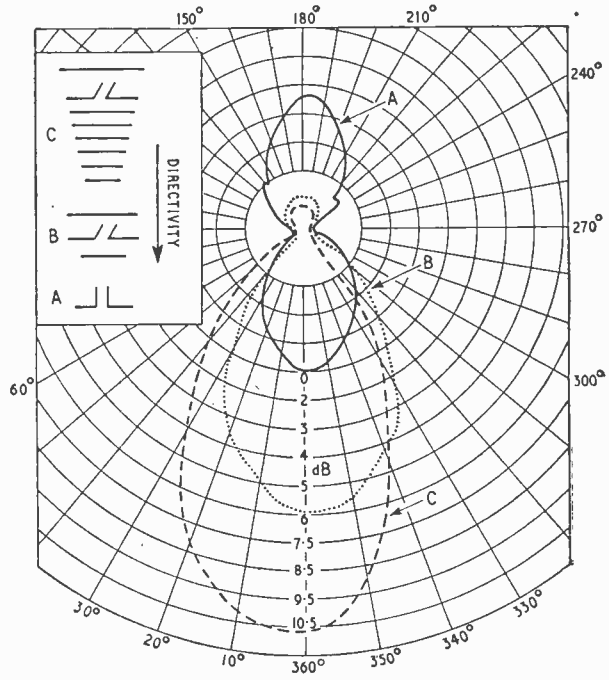


Fig. 9. Gains of 3- and 8-element Yagi aerials compared with a half-wave dipole measured at 3,000Mc/s.

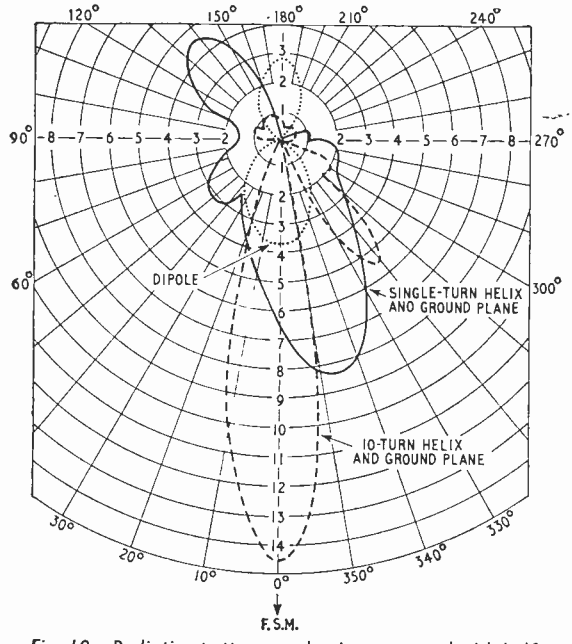


Fig. 10. Radiation patterns and gains compared with half-wave dipole of single-turn helix with ground plane and ten-turn helix with ground plane.

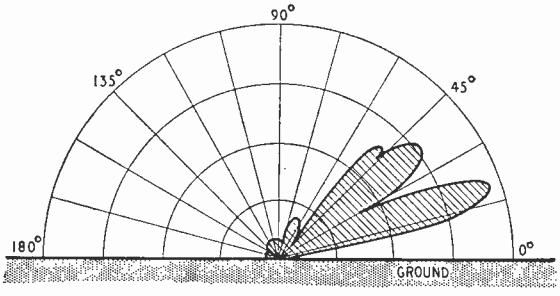


Fig. 11. Vertical radiation pattern of a scale model 2-element "Quad" aerial.

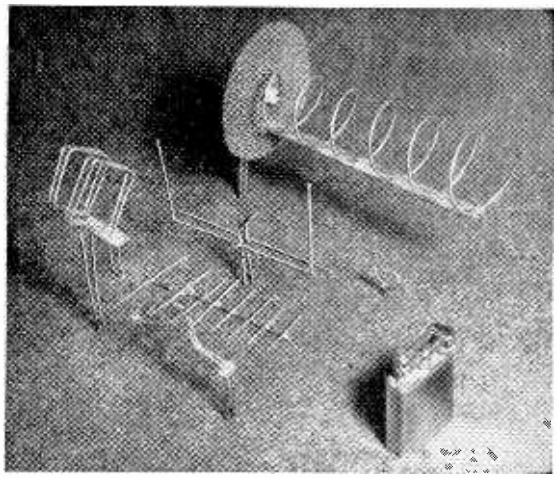


Fig. 12. Some of the scale model aerials used for the measurements described in the text.

Models provide a unique system for testing and estimating the performance of aerials for all the lower radio frequencies up to at least 30Mc/s and offer an excellent method of demonstration during lectures. The writer has used over 100 different models and several aerials suitable for amateur radio transmitting have been developed with the aid of the testing table. Using scale models, a number of enlightening experiments were recently carried out to determine the radiating properties of "loaded aerials" suitable for mobile operation on the 1.8- and 3.5-Mc/s amateur radio bands and for certain applications at frequencies around 30Mc/s.

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[3] F. Charman, B.E.M. "High Frequency Model Aerials," *Proc.R.S.G.B.*—Spring, 1949.

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R. D. Rhodes, *Electronics*—March/49.

J. T. Tiley, *Electronics*—February/52.

F. C. Judd, *Short Wave Magazine*—January/50.

J. D. Kraus, *Electronics*—April/47.

BOOKS RECEIVED

The Radio Amateur's Handbook, 1960 edition, compiled by the American Radio Relay League, West Hartford, Connecticut, U.S.A. First published in 1926 and now widely recognized as the standard manual of amateur radio communication. Chapters devoted to construction of equipment have been extensively revised to include the latest s.s.b. and radio-teleprinter techniques for amateur use. Several chapters are devoted to basic principles clearly explained. Pp. 584 plus 32 pp. of tabulated data on valves and semiconductors with over 1,300 illustrations. Obtainable from leading technical booksellers, also from Radio Society of Great Britain, New Ruskin House, Little Russell Street, London, W.C.1; price 32s 6d (34s by post).

Mullard Reference Manual of Transistor Circuits. More than 60 circuits of audio amplifiers (including p.a.), hearing aids, simple radio receivers, oscillators, switching circuits, stabilized power supplies, etc., with component values, coil winding data and constructional hints. Prepared by the staffs of Mullard Research Laboratories, Applications Research Laboratory and Semiconductor Measurement and Application Laboratory. There are nine introductory chapters on transistor characteristics, equivalent circuits, bias and stabilization and limiting values. Pp. 308; Figs. 241. Mullard, Ltd., Torrington Place, London, W.C.1. Price 12s 6d (13s 6d by post).

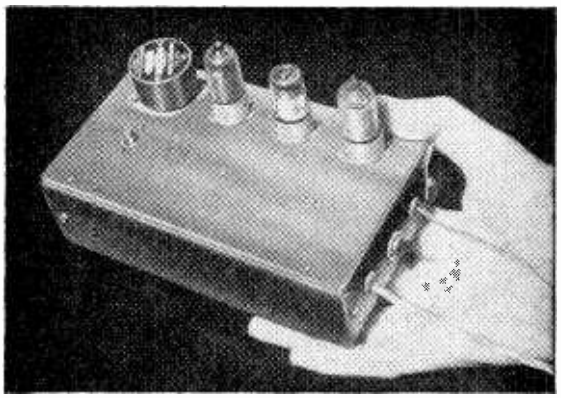
British Semiconductor Guide—1960. Characteristics of 963 semiconductor devices including transistors, diodes and rectifiers and photosensitive devices, with introductory articles on considerations determining the use of valves and transistors, and on transistor parameters and specifications. Pp. 66. Heywood & Co., Ltd., Drury House, Russell Street, London, W.C.2.

Einführung in die Microwellen-Electronik. Teil II Lauffeld-röhren by Drs. Kerner Kleen and Klaus Pöschl. Mathematical treatise on the principles and operation of travelling-wave tubes in general and special types, including backward-wave oscillators and amplifiers. Pp. 192; Figs. 125. S. Hirzel Verlag, Birkenwaldstrasse 185, Stuttgart N.

100-kc/s Crystal Marker

EMBODYING A NEON MODULATOR FOR HARMONIC RECOGNITION

By F. G. RAYER*



The completed crystal marker showing the top plate screwed to the chassis box.

THE use of a 100 kc/s crystal marker, to provide frequency checking harmonics at 100 kc/s intervals, is quite well known. Such a marker is most often employed in conjunction with a communications-type receiver to give exact calibration, or check points at 100-kc/s intervals. Amateur transmitters can employ a marker of this kind to locate the band edges, or for calibrating or adjusting a transmitter VFO. When used with a reasonably accurately calibrated receiver, this method is an acceptable one for frequency determination with amateur transmitting equipment.

The usual simple type of crystal marker has the disadvantage that it is not always possible to distinguish its signal from other signals, especially when tuning to higher harmonics. Even with the receiver aerial removed, other carriers are heard on the crowded short wave bands, so that the crystal marker's signal cannot always be located immediately and without possibility of error. To avoid this, the circuit shown in Fig. 1 is provided with a neon "modulator." This strikes two or three times a second, pulsing the 6BA6 control grid negative, so that the marker signal can always be identified at once. Such a "modulator" does not produce sidebands which would confuse tuning. In addition, the 6BA6 acts as an harmonic amplifier, so that the marker can be used up to about 30Mc/s.

The crystal oscillator stage consists of a 6AM6, with a 100-pF pre-set capacitor for frequency adjustment. The degree of adjustment is quite small, but it allows the crystal frequency to be checked against the B.B.C. 200kc/s Light Programme, or the National Physical Laboratory standard frequency transmissions on 2.5Mc/s, 5Mc/s, and 10Mc/s. Other valves, such as the CV138 or EF91, etc., may be used in this stage. The type of neon is of little importance, provided it will operate with about 150V to 250V. Various other valves could also be utilized instead of the 6BA6.

The unit illustrated was built into a universal chassis 4in × 7in × 2in, with back plate, obtainable from Home Radio (Mitcham) Ltd. The layout employed is shown in Fig. 2. To simplify work the

*Amateur Radio Station G3OGR.

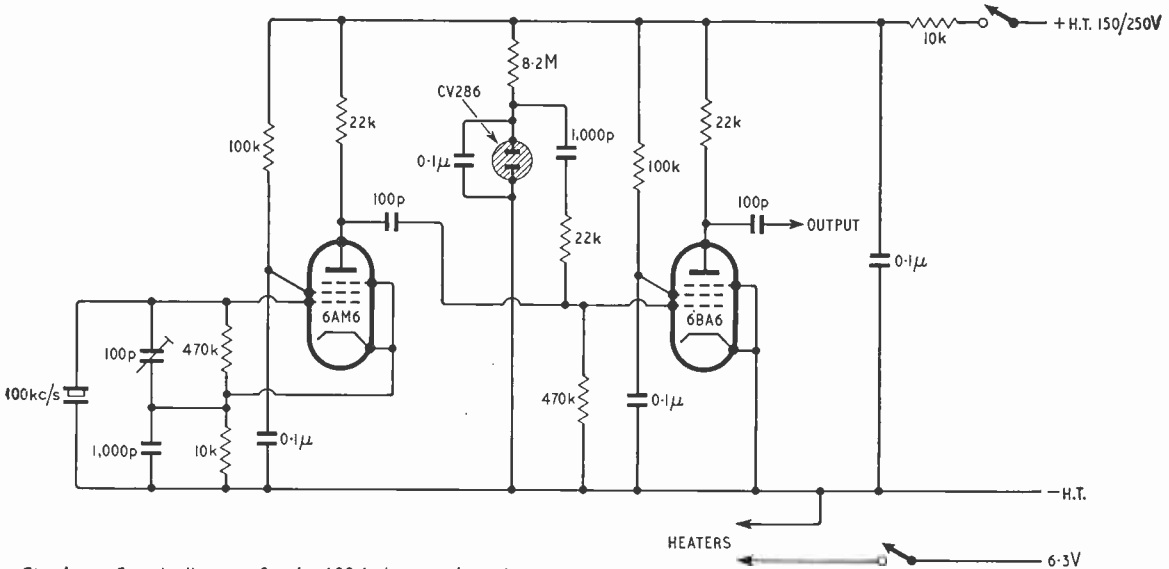


Fig. 1. Circuit diagram for the 100-kc/s crystal marker.

marker was built on the 4in×7in back plate and when completed it was fitted on to the chassis box. For lining up with other equipment it was most convenient to have the heater switch, supply leads, and output at one end of the chassis box. If the marker is connected to its supply only when used, no switch is required, but if it is permanently connected, the h.t. circuit has to be switched, as in Fig. 1, to stop the neon striking.

It is essential that the 100-pF pre-set capacitor is isolated from the chassis. It is also necessary that the 0.1-μF capacitor, in parallel with the neon, should be without appreciable internal leakage, or the neon will not strike. For the same reason the associated 1,000-pF capacitor should be a mica type.

The crystal connections shown in Fig. 2 are for a Quartz Crystal Co's. octal-based Q5/100 crystal unit. This has so low a temperature coefficient that for normal purposes no temperature control is needed, and the crystal stage of the marker is a modified Colpitts intended for use with this crystal. With the component values given, the accuracy of the marker would usually be sufficient even without checking the frequency against the B.B.C. or MSF (Rugby) transmissions.

Power for the unit can often be drawn from the receiver; if not current may be available from a small power pack, or from some other item of equipment. Coupling between the marker and receiver will be sufficient, for lower frequencies, if the marker output lead is placed near the receiver aerial terminal. For the high harmonics, the output lead is connected directly to the receiver.

To check against the B.B.C. or MSF transmissions, tune in the signal, and adjust the marker coupling to the receiver so that its signal is of similar strength to that of the station. In some parts of the country this may mean that no aerial, or a very short length of wire, will suffice. The receiver BFO should not be used, and if the MSF transmissions are chosen they should be at those periods (of the hour) when no modulation is present.

When the 100-pF capacitor is far from its correct setting, the difference in frequency between the crystal marker and the station transmission will be audible as a low pitched flutter. As the capacitor

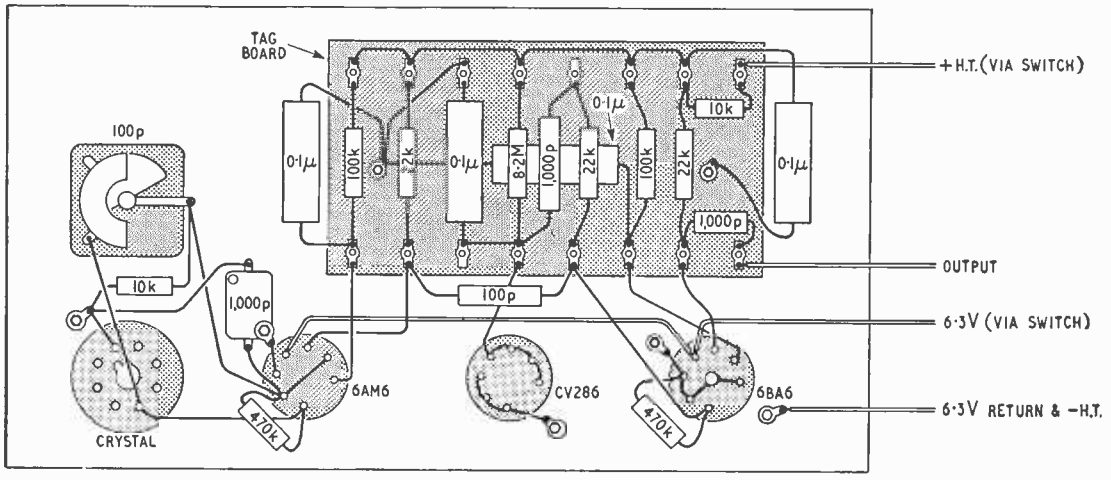
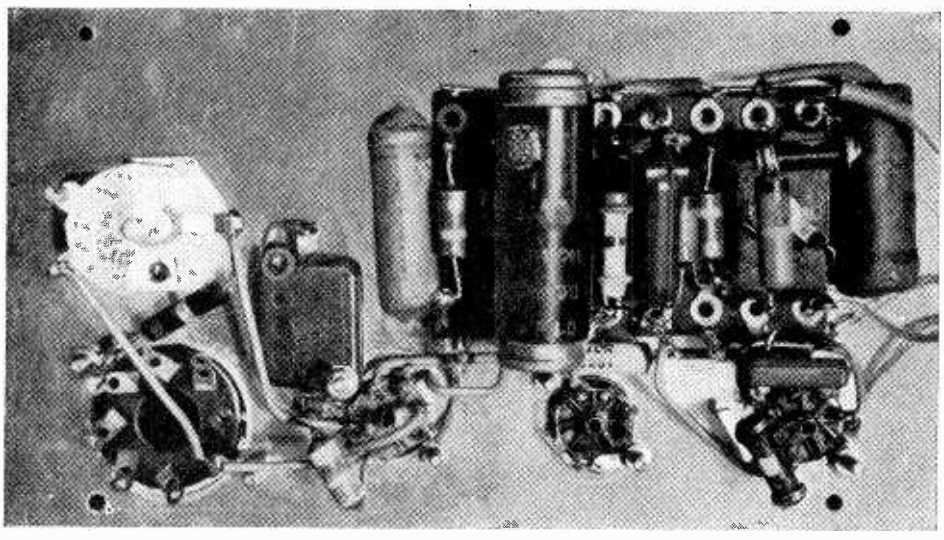


Fig. 2. Layout of components and wiring on the underside of the "top" plate of the chassis box.



This underside view of the top plate should be studied in conjunction with Fig. 2 for identification of the components.

is adjusted towards correct capacity, the rapidity of flutter will decrease. If a tuning meter or indicator is fitted to the receiver, this will rise and fall as the marker and station signals fall in and out of step, and the best setting for the capacitor can easily be located. The B.B.C. 200-kc/s transmissions are easily received in many areas, frequency is maintained to a very high order of accuracy, and adjusting the marker against this frequency is particularly simple.

For checking receiver calibration, the receiver BFO should be switched on, and the aerial removed. The gain controls will need to be quite low for harmonics such as those used to mark the edges of the 1.8Mc/s to 2Mc/s or 3.5Mc/s to 3.8Mc/s bands. For higher harmonics, such as are required to indicate the edges of the 28Mc/s to 30Mc/s band, the receiver gain controls will need to be near maximum.

For signal generator or VFO calibration or adjusting, the BFO should be off, so that the generator or VFO signal can beat with the crystal marker's signal.

Amateurs' National Convention

VARIED R.S.G.B. PROGRAMME AT CAMBRIDGE

THE fourth post-war National Convention of the Radio Society of Great Britain—held at Cambridge from September 15th-17th and attended by some 200 members and guests—was notable for the very full programme of technical lectures and discussions, in addition to visits to places of technical interest and those social functions which are traditional at amateur radio conventions.

The links between radio amateurs and radio astronomers have always been close; indeed the first steerable radio telescope was built by an American amateur and a British amateur played an important rôle in establishing the radiation of radio signals by the sun. The Cambridge convention fittingly included talks by Prof. Martin Ryle (who holds the call G3CY) and Dr. F. G. Smith, of the Mullard Radio Astronomy Observatory. The programme also included visits to the Observatory to see the unique development of aperture synthesis and EDSAC II, the University's computer on which the observations are analysed. One of the radio telescopes now records signals automatically in digital numbers for feeding direct to EDSAC.

Prof. Ryle described the two main aerial arrays which would be capable of detecting a one milliwatt transmitter on the moon and which in June identified radio sources 4,500,000,000 light-years distant—the world's one-way DX record! Present investigations are concentrated on 38 and 178 Mc/s, though work is also being carried out on 81.5 and 408 Mc/s. By aperture synthesis, the 3,200ft, 38 Mc/s fixed array used in conjunction with the relatively small moving section gives results equivalent to a paraboloidal reflector of 1,500ft diameter.

The low-noise maser, parametric amplifier and electron beam amplifier are not exactly standard amateur practice yet (though some interesting work on parametric amplifiers has been carried out by amateurs in the United States and also, on a more limited scale, in this country) but A. H. W. Beck and Dr. F. G. Smith graphically summarised recent research in these developing fields. The Adler tube, with its remarkable ability to separate signal from noise and then to lose the noise, appears particularly promising in view of its relative simplicity of adjustment, wide bandwidth and 25dB or so gain to 3,000 Mc/s—if only prices fall to suit amateur pockets. At the other end of the radio spectrum, Dr. B. H. Briggs, of the Cavendish Laboratory (formerly G2FJD) described investigations into the strange phenomena of the "whistling atmospherics."

The rapidly increasing interest in single-sideband transmission ensured a lively audience for a survey of modern amateur practice by G. C. Bagley (G3FHL)—one of the few British amateurs who can already claim more than ten years' experience of this type of operation. Another topic attracting increasing attention stems from the results now being achieved by members of the British Amateur Radio Teleprinting Group which sprung into being after the first British amateur teleprinter contacts were made last year in the 3.5 Mc/s band.

A most effective demonstration of the present advanced state of amateur television transmission in the U.K.—which appears to lead the world in this specialized branch of amateur radio—was presented by members of the British Amateur Television Club. Two 27in receivers displayed the 405-line transmissions from G3NOX/T at Duddenhoe End, some 15 miles from Cambridge. This station, one of an active network of stations reaching well down into Essex, transmits on 436.3 Mc/s with an e.r.p. of 5.7 kW.

The pictures were of impressively high standard; so incidentally was the programme technique displayed by the team of operators who had pooled resources to provide three camera chains. Transmissions from this group of stations are made regularly on Saturday evenings and can be received over distances of up to about 30 miles on standard television receivers fitted with 70-cm converters. At the end of the demonstration, viewers at Cambridge were able to question the operator (I. M. Waters, G3KKD) at the television transmitter via a duplex radio link on 70cm and 2 metres.

Throughout the Convention transmissions were made on amateur bands from 1.8 Mc/s to 144 Mc/s under the special call-sign GB2CAM.

The convention was rounded off by a dinner at the Guildhall with guests including the Mayor of Cambridge, who had assisted the event in many ways, Dr. F. G. Smith, Brigadier E. J. H. Moppett and Major-General E. S. Cole, now Director of Telecommunications at the War Office, but formerly better known to amateurs as G2EC, SU1EC and SV1EC. General Cole spoke of the effective work of the R.S.G.B. in preserving amateur frequency allocations and of the value of radio communication in encouraging international friendships.—J. P. H.

INTERKAMA

1960

DUSSELDORF EXHIBITION OF AUTOMATION AND INSTRUMENTS

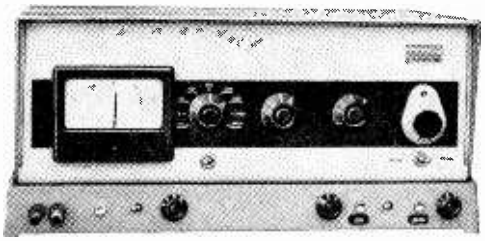
OCCUPYING thirteen exhibition halls of various sizes having a total floor area of nearly 10 acres, the Interkama exhibition and congress was held from 19 to 26 October. 470 exhibitors, 188 from countries other than Germany, displayed equipment for test, measurement, process control, data logging and the myriad other functions required by industry today. There were sections devoted to French, East German and British firms (this latter arranged by S.I.M.A.), but these were not the only displays because many "foreigners" showed their products on the stands of their German agents, or had stands of their own elsewhere in the exhibition.

Industrial Control and Automation

The simplest type of control system uses a man, who makes adjustments by reference to a continuous-reading instrument, as part of a servo loop. The next step is, naturally, the closing of the loop without the man, so that automatic control is achieved. A practical illustration of a closed-loop control system was given by Eckhardt, with a liquid-flow meter and control valve. The sensor uses the Faraday effect of the generation of a potential on a conductor moving in a magnetic field: an electromagnet energized from the mains creates a field across the pipe carrying the liquid. Two electrodes pick out the potential generated by the flow, and this potential is "bucked" or backed off by a servo-driven potentiometer whose motor is energized, via amplifiers, by the difference of potential between the potentiometer and electrodes.

For quality control of a product the recording of the many parameters of a plant must be carried out constantly. The registering, collating and working out of results from these readings can, in a complex plant, consume much time and effort, but this "watchdog" facility can be provided by a central data-processing machine, for instance, the Beckman "123" system. This can accept up to 100 electrical inputs representing plant parameters, scanning each one by a stepping switch in 60sec, processing each input as selected by the position of plugs in a peg board—a zero offset might be required for one input, say, whilst another channel may require a logarithmic amplifier characteristic. The measurements taken can be written out on an electric typewriter or punched-tape system at preset intervals or on demand, and a digital electrical output is available.

"Automation" of processes using small closed loops can have the disadvantage of inflexibility when, say, a chemical process using raw materials of variable quality or where fairly frequent changes in output are required. Each control loop must be reset to a new value each time a change is required, and all the possible combinations must have been worked out beforehand. With more than a very small number of variables it can be seen that the amount of work required could be uneconomical. However, the necessary flexibility can be achieved by opening the individual closed loops and interposing a "communal" computer. Then, by giving the computer the reaction equation and data on raw material purity and price changes the programme can be set to operate the plant automatically for maximum profit.



Macq Electronique drift meter for stabilized power supplies

A system of this type using a Ramo-Wooldridge RW 300 computer to control the manufacture of dodecylbenzene was illustrated on part of the French stand by the Compagnie Européenne d'Automatisme Electronique.

Another point noticed was the widespread use of small-package solid-state logic (such as "and," "or," "not") and instrumentation (timers, amplifiers, etc.) units. There would seem to be a good case here for the various manufacturers to standardise practical details such as mounting, connections and power supplies so that a Siemens "Simatic," say, is directly interchangeable with an Ateliers des Constructions Electronique de Charleroi "Logacec," a Telefunken "Logistat," or a Mullard "Norbit" or "Combi-element."

Instruments

A major feature of the exhibition was the display of instruments for test and measurement, as distinct from automatic control, in the laboratory or the production line. A complete floor of one exhibition hall was divided into "classrooms" in which 56 instrument manufac-

turers gave 249 courses of instruction on their products.

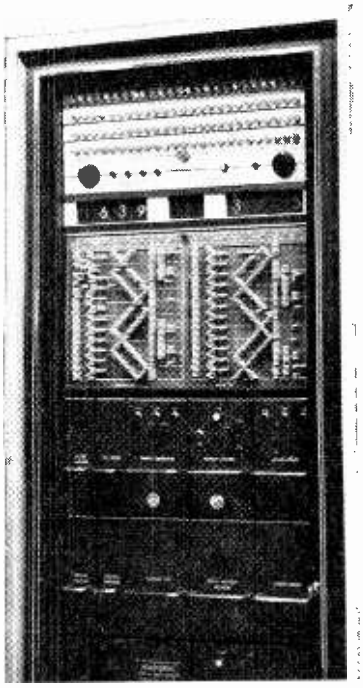
The Wandel and Goltermann WZL-181 test set is designed for the testing of transformer windings. Basically the instrument itself consists of a bridge which can be preset to check coil resistance, turns ratio, etc., a "good" coil returning a zero or "in balance" reading. In the case of unbalance an indication of direction, i.e., high or low, is given. The coil undergoing test is placed in a test jig and connected up; a standard coil induces power, and the tests (including a phase-reverse facility in case the leads have been reversed on connection) can be carried out by the use of push buttons on the jig.

On the General Radio stand small variable delay lines were found. These, having maximum delays of 0.5 and 1μsec are made rather after the fashion of a wire-wound potentiometer, but the winding is skewed on the former to enable a greater length of wire to be in close proximity to a "screen" which forms the capacitive element of the line. This type of variable line is used in the GR 1392A delay generator which can be used for measurements of time intervals as short as 1/100μsec. Another instrument seen here was a transfer-function and immittance (impedance and admittance) bridge for the range 25 to 1500Mc/s, enabling measurements to be made on two, three and "four" (one input and one output earthed) terminal networks. Two calibrated indicator heads are supplied with this bridge, one for each use, and these have small rotatable loops as variable coupling elements to the lines connected to the network under test. The loops are energized from an external generator and a null detector is connected to the junction of the output from the network, a known susceptance and a known conductance. By adjustment of the couplings from the generator to the network input and the resistive and reactive arms, a null can be achieved, when the parameters of the tested object can be read from the calibrated scales of the indicator heads.

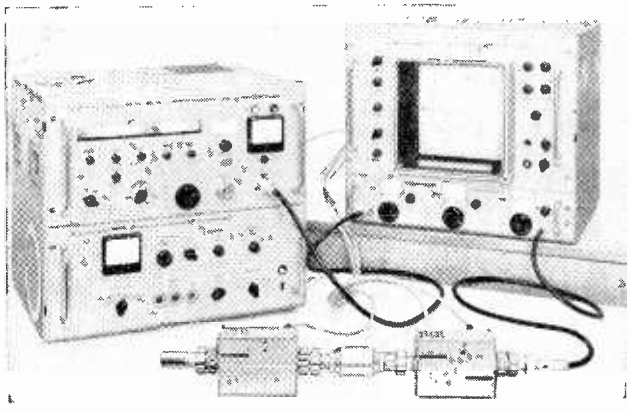
For the testing of many circuits frequency-sweep techniques have immense advantages but until the Carcinotron*, whose frequency can be varied widely electrically, was produced by the C.S.F. the widest sweep available in the s.h.f. bands was somewhat limited. Several manufacturers have produced swept signal generators using Carcinotrons, notably Ferisol (Geffroy et Cie). A generator making its debut at the exhibition was the Rhode and Schwarz Type ZWC. This has a choice of plug-in Carcinotron modules covering the range 1 to 18 Gc/s in (roughly) octave sweeps and constant output is achieved by sampling the signal at a directional coupler at the entry to the test piece so that any anomolous effects due to the cable or waveguide coupling and the three "marker-producing" wavemeters are neutralized. These wavemeters are mounted below the display unit for ease of use, and the display itself offers double-trace working on a 20-cm ($\approx 7\frac{3}{4}$-in) square cathode-ray tube.

The short-term drift, or random variations, of a stabilized power supply are usually so small that they are insignificant. However, if it is desired to know what is happening to one's "stable" supply, the difficulty of measurement has to be overcome. Macq Electronique had on display a drift-meter for this purpose; accepting inputs in the range 1V to 2.5kV, a resistive network is used to drop the applied potential to that of a standard Weston cell contained within the instrument. A mechancial chopper switches between the cell and applied potential, and the resulting a.c. is amplified, detected and applied to a centre-zero meter. The sensitivity of the amplifier can be adjusted so that variations of 1/100,000 or 1/10,000 of the input produce half-scale deflection; also sense (i.e., fall or rise) is indicated.

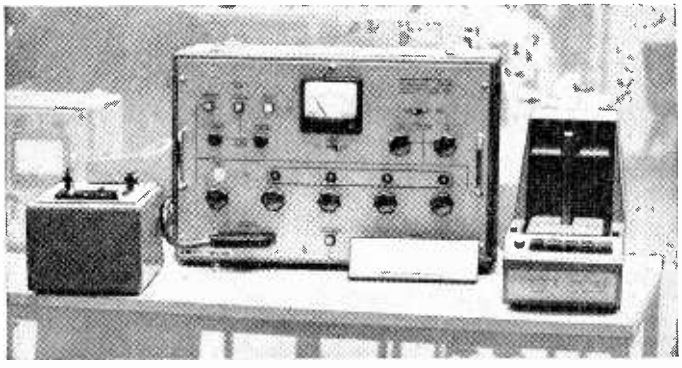
*P.476, *Wireless World*, November 1959.



Beckman Instruments "123" data-logging system. "Peg board" is used for setting up.



Swept signal generator using Carcinotron (Rhode u. Schwarz).



Wandel u. Golterman transformer test set showing the test jigs.

WORLD OF WIRELESS

Commonwealth Telecoms

WITHIN the 62 pages of the 9th General Report of the Commonwealth Telecommunications Board, covering 1959, are reports on the activities in each of the eight partner countries which have nationalized telecommunications systems. The report as a whole is concerned mainly with traffic statistics but there are also some interesting items covering research and developments.

In this country experimental tropospheric scatter transmissions from a transmitter near Bodmin, Cornwall, to receivers near Leafield, Oxon (173 miles) and at West Beckham, Norfolk (300 miles) continued with the aim of obtaining a year's cycle of measurements for analysis of fading characteristics. The tests have included comparisons between multi-channel telephony with f.m. and narrow-band s.s.b. with a.m. and also television with f.m. Tropospheric scatter transmissions from Holland to West Beckham (150 miles) are also being conducted.

The C.T.B., of which Sir Ben Barnett is chairman, consists of a representative from each of the partner governments. Its primary function is the formulation of joint telecommunications policies.

For C.A.R.A.C. read C.C.E.C.A.

WHAT was originally known as the Civil Aviation Radio Advisory Committee has been renamed the Consultative Committee on Electronics for Civil Aviation. Broadly its terms of reference are to provide a forum for discussing U.K. policy in the field of electronics for civil aviation in relation to industrial research and development.

The representatives of the Electronic Engineering Association on the committee are Dr. B. J. O'Kane (Marconi's), K. E. Harris (Cossor) and Air Comdre. C. A. Bell (G.E.C.). The Ministry of Aviation, Admiralty, Air Ministry, B.O.A.C., B.E.A., Post Office, Society of British Aircraft Constructors and the British Independent Air Transport Association are also represented.

Student Exchange

SINCE the scheme for the international exchange of students for technical experience was introduced in 1947, over 52,000 students have participated. During the past year 6,430 took advantage of the scheme, which is operated by 24 countries. The 1960 report of the International Association for the Exchange of Students for Technical Experience records that Germany received the largest number of students (1,195) and also sent abroad the largest number (1,105), with the U.K. second, receiving 909 and sending 883.

The report issued by the U.K. branch shows the distribution by country of the students sent from and received in this country and also by the subjects which they were studying. About 20% (178) of U.K. students went to Sweden, from which the largest number of students (171) came to this country. The address of the London office is 178 Queen's Gate, S.W.7.

B.B.C. Plans

CONTRACTS have recently been placed by the B.B.C. for the building of a number of low-power transmitters to extend and improve its television and v.h.f. sound services. Combined stations are to be erected at Oxford, Llandrindod Wells (Radnor) and Redruth (Cornwall) and a TV station at Manningtree (Essex). Also the site has been chosen for a combined station near Galashiels (Selkirk).

Approval in principle has been given by the P.M.G. for a low-power station near Ballachulish (Argyll). This station is additional to those originally planned for Western Scotland. A point-to-point link was originally to be installed for this part of the route feeding two new stations. It has been decided, however, to build a small auxiliary station which will serve the dual purpose of linking the two stations and providing direct television reception for the people in the area.

Technical Writing

AUTHORS of technical articles on British electronic developments, published during 1960, who wish to compete for the six premiums of 25 guineas each awarded by the E.E.A. and R.I.C., must submit their entries by December 31st. They should be sent to the Electronic Engineering Association, 11 Green Street, London, W.1, and should consist of a copy of the journal* and the relevant pages, proof or reprint. Entries must be accompanied by a signed declaration of eligibility, showing that the entrant is not paid a salary solely for writing and not earning 25% or more of his income from articles or book royalties.

* *Wireless World* is sent by arrangement to each of the judges

Receiver Despatches.—Figures issued by B.R.E.M.A. show that manufacturers' despatches of television receivers during the first nine months of this year were 30% below the same period last year (1,257,000 compared with 1,787,000). Domestic sound receivers and car radio despatches during the same period rose by 23% (1,346,000 against 1,091,000). Radiogramophones, too, rose from 114,000 to 130,000.

Recording Studios.—The revised topographical list of members of the Association of Professional Recording Studios shows that the Association now has a membership of nearly 100 "private professional studios" in this country. It operates a scheme under licence from the Mechanical-Copyright Protection Society, permitting its members to make recordings for private customers of works controlled by the M.P.S.

Satellite Communications.—Technical discussions between American and British officials on matters associated with the possible use of communications systems *via* earth satellites are being held in the U.S.A. The U.K. team is headed by Major General L. de M. Thuillier, of the Cabinet Office, and includes Captain C. F. Booth, W. J. Bray, H. Leigh and F. J. D. Taylor, of the Post Office; J. R. U. Page, of the Office of the Minister for Science; F. E. J. Girling, A. G. Earl and C. Williams (Ministry of Aviation); F. A. Kitchen (Admiralty) and Group Captain A. Foden and C. F. Sutton (Ministry of Defence).

B.C.A.C.—When the British Conference on Automation and Computation, which is a consortium of associations and institutes interested in the field of computation, was formed in 1957 it was divided into three autonomous groups. One dealt with engineering, another control and the third sociological interests. It has now been decided to reconstitute the association with a central council. There are now about 30 societies in the reconstituted B.C.A.C. of which Sir Walter Puckey is chairman with L. T. Blakeman, J. F. Coales and H. G. Conway as vice-chairmen. The honorary secretary is W. K. Brasher, secretary of the I.E.E. which is providing secretarial services.

Local Broadcasting.—A detailed survey of their plans for 100 or more local broadcasting stations in this country has been issued as a 13-page brochure by Pye Ltd. Comparisons are drawn with the situation in the U.S.A. where extensive use is made during daylight of common medium-frequencies by a large number of stations with geographical spacing of 90 miles or less.

Fleming Memorial Lecture of the Television Society will be given by Professor D. M. MacKay on January 26th at the Royal Institution, Albemarle Street, London, W.1. His subject will be "Behind the Eye". Admission is by ticket obtainable from the society, 166 Shaftesbury Avenue, London, W.C.2. Dr. MacKay was recently appointed to the research chair in communication founded by Granada Television at the University College of North Staffordshire.

MARY E. CHAMBERS, of the E.M.I. Research Laboratories, is the first woman to be awarded the Dip.Tech. with first class honours. She has taken a four-year sandwich course at the Brunel College of Technology and E.M.I., where she has been concerned with the preparation of photo-conductors for television camera tubes and phosphors for c.r. tubes.

Publication date.—Owing to the Christmas Holidays our January issue will not be published until December 31st.

The National Radio Show, 1961, will be held at Earls Court from August 23rd to September 2nd with a preview for overseas and invited guests on August 22nd. This, the 28th National Radio Exhibition, will again be organized by Radio Industry Exhibitions Ltd., 59 Russell Square, London, W.C.1.

Aeronautical Electrics and Electronics.—A joint committee, with Professor G. A. Whitfield, of the College of Aeronautics, Cranfield, as chairman, was recently formed by the I.E.E. and the Royal Aeronautical Society to consider ways and means of stimulating discussion of problems of common interest. As a result, joint meetings of the two organizations are to be held in London and plans are being made for the formation of joint groups in the provinces. At the inaugural meeting in London on November 11th, Viscount Caldecote spoke on the future of "electrics" and "electronics" in aircraft and guided missiles.

Transducers.—The Electronic Engineering Association is seeking the help of manufacturers and users in compiling a list of transducers. It is collating information not only on current types but also on those under development. Those interested in helping the association in compiling this list, which will be available to non-members, are invited to send for the questionnaire obtainable from J. F. Richardson, Technical Secretary, E.E.A., 11 Green Street, London, W.1.

Gramophone records produced during the third quarter of the year totalled just over 16M, about 5% more than in the corresponding period last year. There were 59% fewer 78 r.p.m. records produced (688,000 compared with 1,691,000) and 2% fewer 33⅓ r.p.m. discs (3,488,000 against 3,546,000) but 18% more 45's and medium-play (11,860,000 against 10,092,000).

Vacation Courses.—"Introduction to Industry" training courses are again available at the Chippenham Works of Westinghouse Brake and Signal Co. Ltd., for boys who are taking G.C.E. "A" level scientific subjects. Two courses are arranged during the Christmas vacation, January 2nd to 6th, and 9th to 13th. Applications should be made before December 1st.

Engineering aspects of the plastics industry will be covered by a new monthly journal, *International Plastics Engineering*, to be published in association with *British Plastics*. The first issue will appear on February 1st.

INDUSTRIAL GROUPS—3

E.M.I.—Since going to press with the section of this issue in which the third of our series of surveys of industrial groups appears (p. 611), E.M.I. has supplied additional information which brings the total number of companies within the group to nearly 80. The additional companies are:—

E.M.I. (Australia) and its subsidiaries, Television Patents, Marconiphone Co., E.M.I. Finance Corp., Hayes Properties, and Castle Music; the following subsidiaries of Capitol Records Inc.: Ardmore Music Corp., Beechwood Music Corp., Capitol Record Club Inc., Capitol Records Distributing Corp., Capitol Records International Corp., Capitol Publications Inc., Electric & Musical Industries (U.S.), Electric & Musical Industries (Canada), Capitol Records of Canada, Ardmore & Beechwood (U.K.), and Capitol Royal Club of Canada; Edition Accord, Kristall Schallplatten, and Odeon Musikhaus, subsidiaries of Carl Lindstroem; and these ten additional subsidiaries of Morphy-Richards, Morphy-Richards (Cray), Morphy-Richards (Australia), Morphy-Richards (Canada), Morphy-Richards, S. Africa, Morphy-Richards Inc., U.S.A., Morphy-Richards (Nederland), M-R Salgsorganisation A/S, Denmark, Eureka Electric, Astral Equipment, and Yelsen.

Personalities

Major-General E. S. Cole, C.B., C.B.E., has accepted the invitation to become president of the Radio Society of Great Britain for 1961. He has been a member of the society for nearly thirty years and is well known among amateurs by his call G2EC. General Cole was commissioned in the Royal Signals in 1925 and from 1941 to 1946 was Corps Chief Signal Officer. In 1952 he became Chief Signal Officer, Headquarters, Southern Command, and in 1954 was appointed Deputy Chief Signal Officer, Signals Division, S.H.A.P.E. Since 1958 he has been Director of Telecommunications, War Office. General Cole was at one time chairman of the British Joint Communications Board.

Maj. Gen. E. S. Cole

J. K. Laughton

J. K. Laughton, who joined Plessey's Telecommunications Division in 1958 as sales engineer, has been appointed manager of that division. He went to Plessey after 20 years' service in the Royal Navy. He was promoted to Commander in 1954 and was for the last year of his naval career Assistant Director of Radio Equipment (Communications) in the Admiralty.

J. H. H. Merriman, O.B.E., M.Sc., A.Inst.P., M.I.E.E., was recently appointed staff engineer of the Overseas Radio Planning and Provision Branch of the Post Office. For the past four years he has been seconded to the Treasury as the assistant secretary responsible for computer work and policy in all Government Departments. A physics graduate of King's College, London, where he later worked under Professor Appleton on non-linear oscillators for his M.Sc. degree, he joined the Research Station staff at Dollis Hill in 1936. He was closely associated with the development of MUSA—the steerable aerial system.

N. T. Atkinson, formerly head of television development in Ekco, has been appointed to the post of chief of television and radio development. He has been concerned with the development of Ekco television receivers since 1938 and in his new position he will be directly responsible to **A. J. Brunker,** executive director and chief engineer. **E. W. Maynard,** who has been in charge of export television development, succeeds Mr. Atkinson as head of television development.

Dr. J. L. Pawsey, F.R.S., assistant chief of the Division of Radiophysics of the Commonwealth Scientific and Industrial Research Organization, Australia, has been awarded the Hughes Medal of the Royal Society for his distinguished contributions to radio astronomy both in the study of solar and of cosmic radio emission.

Terence B. Tomlinson, Ph.D., B.Sc., A.M.I.E.E., A.M.Brit.I.R.E., joined Southern Instruments earlier this year as chief engineer. He is responsible for design and development for the newly formed company, Drayton-Southern, Ltd. After graduating from London University he became a laboratory demonstrator in electronics at the Cavendish Laboratory, Cambridge. He spent two years with Sobell Industries, returning to the university to take a higher degree—his research being concerned with low-frequency fluctuations of emission from oxide-coated cathodes. Dr. Tomlinson subsequently became a lecturer in electronics at Southampton University, where he stayed for six years before joining the G.E.C. Research Laboratories for work on solid-state physics. He transferred to the G.E.C./I.C.T. subsidiary, Computer Developments, Ltd., where he stayed until joining Southern Instruments.

Dudley Saward, O.B.E., who joined Texas Instruments Ltd. on its formation in 1956, has resigned from the managing directorship in order to devote more time to other activities, but will remain a director of the company. Mr. Saward was chief radar officer, Bomber Command, from 1942 to 1945 and was for some time after the war controller of navigation and telecommunications with British European Airways. He is succeeded as managing director by **A. N. Provost,** a former U.S. naval officer and an engineering graduate of Tufts and New York Universities. Mr. Provost was for some time with Sylvania Electric Products before joining the semiconductor components division of Texas Instruments, Inc., in Dallas, U.S.A.

J. D. Dale-Lace, A.M.I.E.E., D.F.H., the new sales manager of the radio components and special products department of A.E.I.'s Radio and Electronic Components Division, was a technical officer in the Royal Navy from 1940 until 1946 when he joined Pye, where he worked on the development of television transmission equipment. A year later he went to South Africa as technical representative of Sperry's South African agents. He rejoined Pye in 1951 as a telecommunications sales engineer, and since 1956 has been with de Havilland Propellers as guided weapons service manager at Hatfield.

J. D. Dale-Lace

T. J. Murphy

T. J. Murphy, A.M.I.E.E., A.M.Brit.I.R.E., of the engineering division of Radio Eireann, has been given the City and Guilds Insignia Award in Technology (C.G.I.A.) for "his competence in the field of electrical industries (broadcasting—sound and television) and in respect of a thesis on the design of modern sound broadcasting studios." Mr. Murphy had been three years in Pye's final test department before joining the Engineering Division of the B.B.C. in 1943. He left the Corporation in 1951 to join Radio Eireann, Dublin, and for the past five years has been in charge of the studio department of the engineering division.

Colonel H. A. Lewis, O.B.E., T.D., B.Sc.(Eng.), M.I.E.E., A.C.G.I., has relinquished his appointment as managing director of E.M.I. Sales and Service, Ltd., to become managing director of Newmark (London) Distributors, Ltd., precision instrument manufacturers, of Great Portland Street, London, W.1. Col. Lewis has been with E.M.I. since 1956. For the previous six years he was in the Broadcasting Division of Marconi's. From 1933 to 1948, except for the war years when he was in R.E.M.E., Col. Lewis was in the Engineering Division of the B.B.C.

F. W. Perks, sales director of British Radio Corporation Ltd., is retiring. His career in the radio industry extends from 1914 when he joined Marconi's W/T Co. Freddie Perks, as he is affectionately known in the industry, has held many important appointments including the chairmanship of B.R.E.M.A. and B.R.V.M.A. and is at present chairman of Radio Industry Exhibitions Ltd. (organizers of the National Radio Exhibition) and president of the Radio Industries Club. He is succeeded as B.R.C. sales director by **T. B. (Jock) Henderson,** general sales manager of Philco (Great Britain) Ltd., an associate company.

P. A. M. Curry, M.A., B.Sc., has been appointed deputy to **H. St. A. Malleson,** head of Mullard's Government and Industrial Valve Division. After graduating with a first in engineering science at Oxford, Mr. Curry studied for a research degree and was awarded a Henry Fellowship providing a two-year course at Harvard where he obtained the degree of Master of Business Administration.

L. **J. M. Knotts** has joined Mullard Equipment Ltd. as technical adviser on the application of electronics to railway signalling and communication systems. He was formerly signal engineer to the Scottish Region of British Railways.

F. S. Barton, C.B.E., M.A., B.Sc., M.I.E.E., who, as announced in October, has retired from the Civil Service, has joined the board of Painton & Co., Ltd., of Northampton.

Keith Lockyer, B.Sc., A.M.I.E.E., A.M.Brit.I.R.E., has been appointed general manager of Donvin Instruments Ltd., and Dumar Optics Ltd., the instrument, camera and tape recorder repair firms which are part of the R. B. Pullin group.

Dr. T. W. Straker is deputy manager of Marconi's Radar Division and not manager as was inadvertently announced in our last issue. The manager of the division is **E. N. Elford,** O.B.E., A.M.I.E.E.

H. M. Palmer has retired from Marconi International Marine after nearly 50 years' service. He has been in charge of the company's Fleetwood service depot for the past 25 years. He is succeeded by **J. E. Dallaston** who joined the company in 1931 as a sea-going radio officer, as did Mr. Palmer.

G. H. W. Johnson, Assoc.Brit.I.R.E., for the past three years marine director of Marconi (South Africa) Ltd., has relinquished his seat on the board and has joined Norsk Marconikompani A/S in a similar capacity. Mr. Johnson joined the Marconi organization as a radio officer in 1938.

G. A. Dwyer, manager of the Marconi Marine Co.'s Bombay depot from 1952 to 1954, has been appointed the company's representative in India and Ceylon. He joined Marconi's sea-going staff in 1929. In 1941 he was appointed to the shore technical staff at Glasgow and three years later was seconded to the Naval base at Ardrossan.

Angela M. Lane has been appointed administrative secretary of the Television Society. She joined the secretariat of the Society in 1955 and has been assistant secretary for some time. **Geoffrey Parr,** the honorary secretary of the Society since 1945, who recently entered hospital for heart trouble, is now convalescing.

OUR AUTHORS

G. W. H. Larkby, author of the article describing a remotely controlled TV camera designed by the B.B.C., has been with the Corporation since 1936, except for the war period when he served with the R.A.F. in 60 Group (Radar). On his return to the B.B.C., Mr. Larkby was attached to the outside broadcast department of the Television Service. He later transferred to the Designs Department where he has been chiefly concerned with the many complex electro-mechanical and optical problems in the television field.

J. W. Bunn, joint author of the article on ceramic permanent magnets, is powder metallurgist with Swift Levick and Sons, with whom he has been associated for 13 years. In 1954 he gained the associateship in metallurgy from the University of Sheffield where he had undertaken part-time study. He is a licentiate of the Institute of Metallurgists. **J. Harrison,** his co-author, is magnet design engineer with Swift Levick. He was previously assistant metallurgist at the central research laboratory of the Permanent Magnet Association.

F. C. Judd, contributor of the article on aerial measurements, is a free-lance technical writer. Until making writing his full-time occupation, he was in the radar research laboratory of Kelvin & Hughes.

OBITUARY

Dr. G. W. O. Howe, Emeritus Professor of Electrical Engineering of Glasgow University, died on November 7th, aged 84. Professor Howe was successively technical editor of and consultant to our sister journal *Wireless Engineer* (now *Electronic Technology*) for over 30 years. In 1956 he was awarded the Faraday Medal of the I.E.E. for "his pioneering work in the study and analysis of high-frequency oscillations and on the theory of radio propagation; and for his outstanding contributions to engineering education." Dr. Howe, who was apprenticed to Siemens at Woolwich, went to Imperial College as a lecturer in 1905 and in 1921 was appointed James Watt Professor of Electrical Engineering at Glasgow University, the position he held until his retirement in 1946 when he was appointed an Emeritus Professor. Dr. Howe was a great teacher and his editorials in *Wireless Engineer* over very many years were an outstanding contribution to electrical and radio theory. In recognition of "his contributions to the advancement of radio science and in particular for his long series of notable editorial articles in *Wireless Engineer*", he was, in 1956, elected an honorary member of the Brit.I.R.E.

Professor Bernard Hague, D.Sc., Ph.D., F.C.G.I., D.I.C., M.I.E.E., who had occupied the James Watt Chair of Electrical Engineering at Glasgow University since 1946, has died aged 67. His academic career began in 1920 when he became a lecturer at the City and Guilds College, prior to which he was for four years at R.A.E., Farnborough. Dr. Hague was a lecturer at Glasgow University from 1923 until 1929 when he went to the Brooklyn Polytechnic Institute, N.Y. He returned to Glasgow as senior lecturer in 1930.

Reginald Lawler, manager of the Electronics Division of Ferguson Radio Corporation, which he joined in 1938 as a radio development engineer, died on November 2nd, aged 59. He was at one time in charge of the company's factory at Hirwaun, Glamorganshire, but returned to Enfield in 1952.

News from Industry

Pye-Ekco Merger.—The boards of Pye Ltd. and E. K. Cole Ltd. have recommended to their shareholders a merger of the two companies through a holding company, as yet unnamed. C. O. Stanley would be chairman and E. K. Cole deputy chairman. Pye will have a 75% holding in the new company and Ekco 25%. Their combined assets are nearly £25M.

Plessey-Garrard.—Agreement has been reached in principle under which the Plessey Company would acquire all the issued share capital of the Garrard Engineering and Manufacturing Co. If the offer is accepted Garrard will continue as a separate entity under its own board of directors with Hector V. Slade as managing director.

Cossor.—Major-General Sir Miles Graham, who succeeded the Marquess of Exeter as chairman of A. C. Cossor Ltd. last March, reported at the annual general meeting that for the year 1959/60 the group trading profit was £127,699, compared with £534,260 the previous year. There was, however, a net loss of £97,977. The group includes Cossor Radar & Electronics, Sterling Cable Co., Cossor Communications, Cossor Instruments, Lea Bridge Cabinet Works and Best Products.

Baird.—Radio Rentals Ltd. have entered into an agreement to purchase Baird Television Ltd., and will market television and sound receivers bearing the name "Baird." All the company's sets are made in Bradford by its Bradford manufacturing subsidiary, Mains Radio Gramophones, and will in future carry the new trade name.

BMEWS.—R.C.A. Great Britain Ltd., the U.K. associate of the Radio Corporation of America, is "weapon system contractor" for the Fylingdales, Yorks., base for the American ballistic missile early warning system. It is estimated that the cost of the whole Fylingdales project will be $115M. Work has already begun on this, the third site for the BMEWS chain (see *Wireless World*, July, 1960, p. 335).

Eimac.—In association with the development of new Eimac klystron valves for high-power radar and communications, Eitel-McCullough are building a "superpower" supply unit drawing 12 amps at 282kV (approximately 3MW). Agents for Eimac products in the U.K. are Walmore Electronics Ltd., Phœnix House, 19/23 Oxford Street, London, W.1.

Trav-ler Tape Recorder.—This transistor battery/mains portable tape recorder introduced at the National Radio Show by Casian Ltd., is being produced by Aerialite Ltd., of Hargreaves Works, Congleton, Cheshire, who have acquired the manufacturing and distributing rights.

Balzers High Vacuum Ltd. has been formed, with offices at 1 Mornington Terrace, Regent's Park, London, N.W.1, to handle in this country the products of Balzers A.G., of Liechtenstein, including equipment for high-vacuum metallurgy and coating, vacuum pumping gear and measuring instruments.

Grundig.—To mark the sale of the 100,000th Grundig TK20 tape recorder in the U.K., G. S. Taylor, managing director, presented the 100,001st model to the Royal National Institute for the Blind at a recent ceremony in London. It is understood that it has already been assigned to the Chorley Wood College for Girls.

Air-to-Ground Telemetry.—A consortium of five British manufacturers has been formed on the recommendation of the Ministry of Aviation to exploit the overseas and U.K. markets for a major air-to-ground multi-channel telemetry system. This has been developed by the member companies in collaboration with the Royal Aircraft Establishment, Farnborough. The members are: Elliot Brothers (London) Ltd., McMichael Radio Ltd., Rank Cintel Ltd., Southern Instruments (Contracts) Ltd., and W. S. Electronics Ltd., who have been appointed to act on behalf of the consortium.

Thermionic Products (Electronics) Ltd., of Hythe, Southampton, have ceased manufacturing domestic tape recorders and dictating machines. A limited supply of spares will be available until the end of next year. The company is concentrating on the production of multi-channel recorders for airport communications logging and other fields of data logging.

Marconi's have received a further order valued at over £93,000 for the supply of translators, amplifiers and associated equipment for the B.B.C. The equipment will be used in the first stage of the Corporation's programme for the extension of its television and v.h.f. sound services by satellite stations.

Vactric (Precision Tools) Ltd., and Vactric (Control Equipment) Ltd., subsidiary companies of Vactric Ltd., which was recently put in the hands of a receiver, are continuing to operate as separate entities.

Texas Instruments France, with headquarters in Nice, has been set up by the Dallas company to manufacture semiconductor devices and components for the European Common Market.

EXPORTS

I.L.S.—Through their Canadian associates, Pye Telecommunications Ltd. have received a contract from the Royal Canadian Air Force for the supply of an instrument landing system for installation at the R.C.A.F. Airfield, Trenton, Ontario. This is said to be the first installation of British I.L.S. in the western hemisphere.

Montreal's two new commercial television stations are to be equipped by Marconi's with duplicate 18-kW vision and 9-kW sound transmitters. Each station will transmit a bilingual service (English and French).

Broadcasting Transmitters.—British Sarozal, of 22 Berners Street, London, W.1, have recently supplied a number of short-wave and medium-wave broadcasting transmitters to Africa. They include a 5-kW transmitter for Radio Pax, in Beira, Mozambique, which will radiate on 3.952 and 7.205Mc/s and another for Praia, Cape Verde Islands, for operation on 3.960Mc/s.

Communications Equipment.—Racal, of Bracknell, Berks., have received through their agents, Instronics Ltd., of Stittsville, Ontario, three major orders for communications equipment from the Canadian Department of Defence Production. They have a total value of £560,000.

Multi-lingual Catalogue.—Alfred Imhof Ltd., of 112/116 New Oxford Street, London, W.C.1, have produced an international version of their catalogue of racks, cases, consoles and accessories, every item being described in ten languages (English, French, German, Spanish, Italian, Portuguese, Dutch, Swedish, Norwegian and Danish).

Ceram'c Permanent Magnets

By J. W. BUNN*, A.Met., L.I.M., and J. HARRISON*

A relatively recent addition to the range of magnetic materials is the barium ferrite ceramic permanent magnet[1]. This material, commercially available under a variety of trade names, e.g. Feroba, Magnadur, Caslox, Indox, Oxit, etc., is basically an oxide compound having the formula $BaFe_{12}O_{19}$. It is non-metallic and, in common with other ceramics, is hard, brittle, a non-conductor, and relatively light in weight when compared with alloy magnets. These properties together with its unique magnetic characteristics have opened up a new field in magnet applications.

Barium ferrite, although of similar appearance to the more commonly known "soft" magnetic

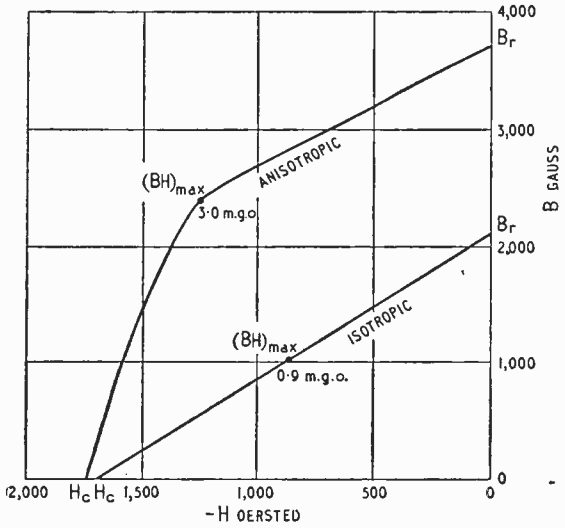


Fig. 1. Demagnetization curves for barium ferrite.

core materials, is distinct from this class inasmuch as magnetically soft materials are characterized by high permeability and low losses when used in an a.c. circuit, whereas barium ferrite is a magnetically hard material possessing a high coercivity, remanence and energy product $(BH)_{max}$. The compound $BaFe_{12}O_{19}$ has a hexagonal crystal structure with one axis of easy magnetization parallel to the hexagonal axis. This uniaxial crystal anisotropy together with a small crystal size (approximately 1 micron) is largely responsible for the high coercivity of this material compared with a "soft" magnetic ferrite which has a cubic crystal structure, i.e. three easy directions of magnetization, resulting in low coercivity.

Magnetic Properties.—An essential feature of a permanent magnet is its ability to withstand demagnetization, and this is directly related to the coercivity of the material. Barium ferrite has an exceptionally high coercivity of the order of 1600 oersted, compared with 600-650 oersted for Alcomax alloys, which is responsible for its ability to withstand high demagnetization effects such as a.c. fields, repulsion by other magnets, and excessive mishandling. Its high coercivity coupled with low permeability makes it possible to use ceramic magnets to minimize magnetic leakage fields of magnetic circuits and so increase the overall efficiency of the assembly.

Of the two further properties, remanence B_r and energy product $(BH)_{max}$ the former is a measure of the magnetization remaining in a material when the applied field is reduced to zero, and the latter is the maximum product of B × H on the demagnetization curve, shown in Fig. 1.

The low saturation magnetization[2] of barium ferrite leads to comparatively low B_r and $(BH)_{max}$, typical values for the isotropic variety being shown in Table 1.

Additional properties of permanent magnets which are sometimes required are the incremental or reversible permeability, and the maximum useful recoil energy[3]. In isotropic barium ferrite these values are 1.2 and 0.7 m.g.o. (mega gauss-oersted) respectively, from which it is seen that the recoil

TABLE 1

PROPERTIES OF BARIUM FERRITE COMPARED WITH ALCOMAX III

	Isotropic $BaFe_{12}O_{19}$	Anisotropic $BaFe_{12}O_{19}$	Alcomax III
Remanence B_r (gauss) ..	2100	3700	12,800
Coercivity H_c (oersted) ..	1700	1750	675
Maximum energy product $(BH)_{max}$(m.g.o.)	0.9	3.0	5.5
B_w at $(BH)_{max}$(gauss)	1000	2400	10,200
H_w at $(BH)_{max}$(oersted)	900	1250	540
Recoil permeability	1.25	1.15	3.5
Maximum useful recoil energy (m.g.o.) ..	0.7	1.0	1.5
Temperature coefficient of magnetization (%/°C) ..	−0.2	−0.19	−0.02
Curie temperature (°C) ..	450	450	860
Resistivity (ohm-cm)	1×10^6	1×10^6	55×10^{-6}
Density (gm/cc)	4.8	5.0	7.35
Magnetizing field for saturation (oersted) ..	10,000	8,000	3,000

*Swift, Levick & Sons, Ltd.

energy is 47% of that of Alcomax III alloy magnet material, whereas the total energy $(BH)_{max}$ is only 18% of that of Alcomax III. In view of the comparatively low cost of barium ferrite a definite economic advantage is gained by using this material under recoil conditions. Other features of the recoil properties are dealt with in the section on design and applications.

The Curie point of this material, i.e. the temperature at which for practical purposes the material ceases to be magnetic, is 450°C, so that all traces of magnetism can be removed by heating to above this temperature. For barium ferrite, this is the best method of demagnetizing, but this method cannot be used for normal alloy magnet materials.

A serious disadvantage of barium ferrite is its high temperature coefficient of magnetization which

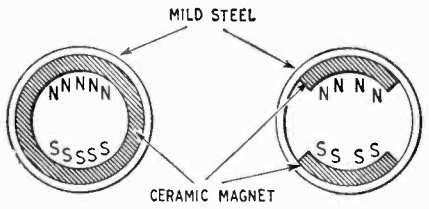


Fig. 2. Isotropic ceramic magnets for d.c. motor stators. Continuous cylinder (left) segments (right).

at $-0.2\%/°C$ is some ten times greater than that of normal alloy magnets. This excludes the use of barium ferrite for, say, measuring instruments, unless elaborate temperature compensating devices are included.

The resistivity of barium ferrite is of the order of 10^6 ohm-cm, and this is of great importance in h.f. applications.

A density of 4.8 gm/cc is usual, which can be advantageous where weight considerations are paramount.

In 1952, Rathenau and others[4] found that by aligning the crystallites of this material when in powder form by means of a strong magnetic field, an anisotropic effect was observed in the direction of the aligning field. Following this, intensive work by different workers[5] in various parts of the world has led to the anisotropic variety which has a higher remanence and a $(BH)_{max}$ some three times greater than isotropic barium ferrite.

At the time of writing, only the isotropic form is commercially available in large quantities in this country. Table 1 gives typical properties of both isotropic and anisotropic barium ferrite, together with the more commonly known alloy material Alcomax III. Demagnetization curves for both varieties of barium ferrite are shown in Fig. 1.

Manufacture.—The basic ingredients are iron oxide Fe_2O_3 and barium carbonate $BaCO_3$ which are mixed in the correct proportions and then heated in air at 1000°C approximately to form the required compound $BaFe_{12}O_{19}$. This is followed by ball-milling to a very small particle size, after which a binder is added and the powder pressed to the required shape by normal powder metallurgy techniques. The compacts so formed are then fired by heating to approximately 1200°C in an oxidizing atmosphere. The density of the fired compact is about 90% of its solid density, and volume shrinkage occurs, the final compact being approximately five-eighths by volume of the pressed compact.

The anisotropic differs mainly from the above isotropic variety in that the ball-milled powder is magnetically aligned in the required direction during the pressing process. This alignment is achieved by applying a high magnetic field to the powder, which can be either dry or in the form of a slurry, whilst the powder is in the die. To obtain precise dimensions, the finished magnet may be ground, but normal drilling and machining methods are impracticable due to the brittle nature of the ceramic material.

After mechanical inspection and magnetic testing for quality, final magnetizing is carried out, when a force of 7000 ampere-turns per centimetre length of material must be applied to achieve saturation.

Design.—In the design of permanent magnets or magnetic circuits incorporating permanent magnets, the aim is to produce the required performance in the most economical manner. In other words, the most efficient use of the magnetic material must be obtained.

Reference has already been made to the demagnetization curve and the three properties B_r, H_c, and $(BH)_{max}$ of a magnetic material, and these are the main features of the material used by the design engineer.

In the majority of permanent magnet applications it is desired to achieve a given magnetic field strength within the confines of a finite gap. In a gap of length l_g and area a_g, where H_g is the field required in the gap,

$$H_g l_g k = H_w L_m \quad \ldots\ldots\ldots\ldots (1)$$

where L_m = length of magnet material
H_w = demagnetizing force
k = reluctance factor.

The demagnetizing force H_w is the value at the particular operating point selected for the design on the demagnetization curve, and k is a factor to allow for the total reluctance of the magnetic circuit and usually has a value of between 1.1 and 1.3.

If B_w is the simultaneous induction value at point H_w on the demagnetization curve, then the total flux required in the gap is:—

$$H_g a_g K = B_w A_m \quad \ldots\ldots\ldots\ldots (2)$$

where A_m = magnet cross-sectional area
K = leakage factor

Combining (1) and (2) we have:—

$$V_m = \frac{H_g^2 v_g K k}{B_w H_w} \quad \ldots\ldots\ldots\ldots (3)$$

where V_m = volume of magnet material
v_g = gap volume

from which it is seen that the minimum volume of magnet material required to produce a given gap energy is obtained when the product $B_w H_w$ is a maximum. Hence it follows that the most efficient design will be obtained when the magnet geometry is constructed so that the point $B_w H_w$ coincides with the $(BH)_{max}$ point of the particular magnet material used in the design. For isotropic barium ferrite operating at $(BH)_{max}$ the value of B_w is 1000 gauss and H_w is 900 oersted.

The above holds for all designs and magnet materials used, but in the use of ceramic barium ferrite the high value of H_w makes practical much shorter lengths than is normal for other materials,

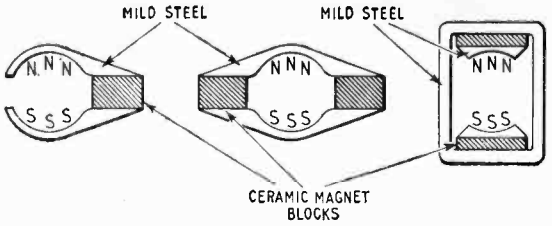


Fig. 3. Three typical methods of using anisotropic ceramic magnets as d.c. motor stators.

although greater magnet areas are required due to the lower value of B_w.

Dynamic Applications — Generators and Motors.—Despite the low value of B_w, the high coercivity of barium ferrite makes it greatly superior to other commercial permanent magnet materials in its ability to reproduce substantially the same flux after being subjected to adverse conditions. Demagnetizing fields of the order of the coercive force of the material may be applied and, upon removal, approximately 97% of the flux is recovered. Subsequently applied demagnetizing fields equal to or less than the coercive force will have no further effect on the resultant flux after removal of the demagnetizing field. From this it is seen that a magnet working at any point on the demagnetization curve after having been subjected to a demagnetizing force will return to its original working point. This unique recoil property opens up new fields in permanent magnet applications.

As outlined above, the most efficient design is achieved by operating the magnet at $(BH)_{max}$. With conventional alloys this is in the main achieved by incorporating the magnet in a flux carrying or mild steel assembly and to obtain optimum efficiency magnetization must be carried out after assembly. Owing to the favourable recoil properties of isotropic barium ferrite, magnetization may be carried out prior to assembly. This obviates the necessity for complicated and often costly magnetizing jigs and fixtures.

In bicycle dynamos and generators using a permanent magnet rotor, it is common practice to magnetize an alloy magnet before assembly in a jig, from which it is pushed directly into a mild steel ring to act as a keeper to maintain a closed magnetic circuit. It has then to be transferred in a similar manner into the stator. When barium ferrite is used, none of these precautions is necessary as the rotor may be open-circuited after magnetization without impairing the performance of the generator. Furthermore, the rotor of such a generator or any barium ferrite magnet in any assembly may be totally removed from the circuit and replaced without the necessity to remagnetize the magnet to maintain the performance after reassembly. This allows for the assembly to be dismantled and reassembled if required.

A further property of barium ferrite arises from the combination of high coercivity and low permeability which makes it possible to place poles of opposite polarity in close proximity without progressive self-demagnetization effects occurring. As many as 24 poles can be impressed on the outer surfaces of a plain cylinder of 1in diameter. The limiting factor to the number of possible poles is the difficulty of producing a magnetizing fixture to provide sufficient field to obtain magnetic saturation.

Ceramic permanent magnets may also be used in the construction of d.c. motors to provide direct current fields. Here again the high coercivity and low recoil permeability play an important part. Owing to the low flux density of this material it is necessary to provide the maximum possible magnet area in the stator, and at the same time the high coercivity enables short radial lengths to be employed. In all magnetic circuits greater efficiency is obtained by placing the magnet material as close as possible to the gap. With these considerations in mind, the simplest and most efficient method of using isotropic barium ferrite for d.c. motor fields is to have the magnet in the form of plain cylinders or segments which in themselves constitute the pole pieces (Fig. 2). In view of the low permeability of this material it is necessary to provide a low reluctance return path to complete the magnetic circuit, conveniently in the form of a mild steel ring which also serves as the motor housing. The magnetic characteristics of the material allow air gaps between three and four times those used in normal motor construction, and also allow for variations in air gap. This means that magnets in the "as fired" condition may be used, so obviating a costly internal grinding operation. For larger motors where the flux provided by isotropic barium ferrite would be insufficient, the anisotropic variety can be employed, but in this case pole pieces would normally be required in order to provide a radial field. Three typical constructions are shown in Fig. 3 using anisotropic magnet b ocks. Similarly, isotropic and anisotropic ceramic magnets can be

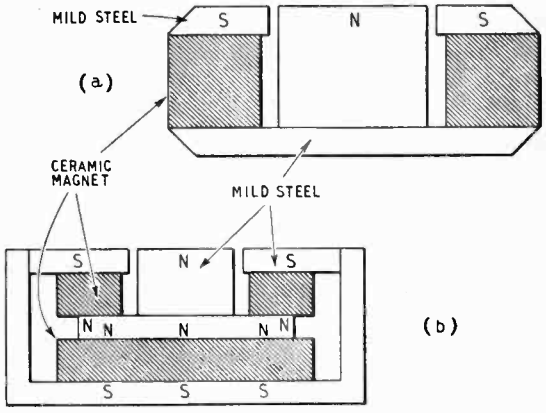


Fig. 4. (a) Ring type loudspeaker assembly (b) Pot type assembly.

used to provide the field energy for flywheel magnetos such as are commonly used in small two-stroke engines.

Radio and Television Applications.—In the domestic radio and TV receiver field, the main use of permanent magnet is in moving coil loudspeaker assemblies. The main advantage of the ceramic magnet over the alloy magnet in this field is an economic one due to the very low cost of the raw materials used. In loudspeaker design, only the anisotropic variety is considered because the

lower B_w of the isotropic material leads to designs having unwieldy and bulky dimensions.

The magnetic properties of anisotropic ceramic material lead to designs which, although having large magnet area, have exceptionally short axial length (Fig. 4(a)). This is important where space considerations are vital, as in midget portable receivers, tape recorders, etc. Two main constructions are used for loudspeaker magnet assemblies incorporating anisotropic barium ferrite, namely ring type and pot type, as shown in Fig. 4. The latter may only be used for low gap field strength assemblies, but has the advantage of having little or no external field. This factor assumes importance in television receivers where stray magnetic fields adversely affect the c.r.t. performance. This pot assembly requires a dual magnet construction in order to utilize barium ferrite to its best advantage dimensionally[6]. A similar magnet construction to loudspeaker assemblies is used for vibrators, moving-coil microphones, and for punch card actuators.

Extensive use has been made of ceramic magnets for television tube focusing units, the high coercivity enabling two isotropic rings axially magnetized to be used in opposition. Changing the

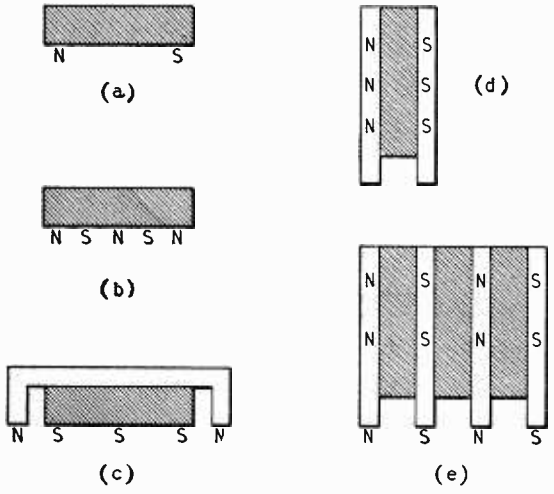


Fig. 5. Holding assemblies using ceramic magnets.

axial distance between the two rings alters the axial field strength distribution and also the working points of the two magnets, thereby changing the field strength of the magnetic lens.

Ceramic magnets are also used in conjunction with television picture tubes as ion trap and picture shift devices and as correction magnets for wide angle tubes.

Holding Applications.—Magnetic holding force is proportional to B^2A, where B is the flux density at the contact faces, and A is the contact area. Taking for example a thin rectangular block of isotropic barium ferrite, there are several methods of utilizing this as a holding device, as shown in Fig. 5. The simplest method of magnetizing is shown in Fig. 5(a), where two poles are impressed on one contact face. Since the pull of a magnetic device is proportional to the product B^2A, a greater pull is obtained by impressing a number of poles on one face, as in Fig. 5(b). This is possible with barium ferrite due to the high coercivity which reduces the effects of self-demagnetization. In order to achieve a higher B, advantage can be taken of the possible high magnetic saturation values of soft iron or mild steel. Typical arrangements are shown in Fig. 5(c), (d), and (e). Here it is seen that the mild steel is suitably proportioned to collect and concentrate the low density flux from a large area of magnet to provide a high flux density at the contact areas. Using a construction similar to Fig. 5(c), with an isotropic disc magnet inside a mild steel cup, an assembly 3in diameter and 7/16in deep would lift approximately 70lb, i.e. over one hundred times the assembly weight. Using an anisotropic magnet, the assembly would be 3in diameter and 3/4in deep, and should lift over 100lb. Construction Fig. 5(d) is widely used for applications like magnetic door catches as it has the advantage of occupying very little space. When used for such applications as magnetic separators, chucks and jigs, multi-assemblies as in Fig. 5(e) have the advantage of providing a greater number of poles in any given area than can be obtained using any other magnet material.

Magnets in the Presence of A.C. Fields.—The high resistance to demagnetization combined with a high resistivity allow ceramic magnets to be used in conjunction with fairly strong a.c. fields. Typical applications are vibrating armatures where the armature consists solely of ceramic magnet material. Alternatively, a mild steel armature inside an a.c. actuated coil may be used. This is made a close fit inside a ceramic magnet ring having mild steel pole pieces which polarize the central armature, so imparting a vibrationary motion. This principle is made use of in bells, small pumps, etc.

A similar principle applies to polarized relays.

Other Applications.—There are many other uses for which ceramic magnets may be used with advantage due to their unusual magnetic characteristics, low weight, or for economic considerations. Amongst these may be cited: remote control services, magneto-mechanical coupling possibly operating through gas-tight seals, arc blowouts, snap contact switches, travelling wave tubes, synchronized artificial eyes, toys and novelties. Barium ferrite may be embodied in plastic or rubber to form a flexible magnet material for such purposes as magnetic seals, etc.

Conclusion.—From the foregoing, it is seen that the advent of barium ferrite magnets has broadened the field of applications of permanent magnets in addition to providing an economically advantageous alternative, in some cases, to conventional alloy magnets. The unique properties of this material provide a stimulus for further investigation of its many and varied possibilities.

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NODAL ANALYSIS

By F. R. B. JONES*, A.M.Brit.I.R.E.

2.—ACTIVE NETWORKS : VALVES AND TRANSISTORS

IN the first part of this article we introduced nodal analysis to new students, showing how it is complementary to mesh analysis. In mesh analysis we use constant-voltage generators and equate known voltages to find unknown current magnitudes. In nodal analysis we employ constant-current generators and equate known currents to find unknown voltage magnitudes.

In this second part we propose to indicate a method by which "active" networks (i.e. those which contain a generator such as a thermionic valve or transistor) may be solved. The method will be identical with that used for passive networks, except for one additional convention.

Network Theory with Valves.—Every student knows that although the anode characteristics of a valve are far from straight, it is still possible to work the valve in a linear mode by avoiding the lowest parts of these curves, where the curvature is worst, and by carefully selecting the position of the load line, so as to work in Class A1. If, in addition, the part of the characteristic worked over is small, we can almost certainly assume linearity with negligible error. Idealized triode and pentode characteristics are shown in Fig. 1(a) and (b).

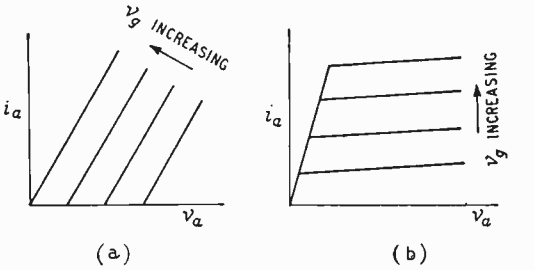

Fig. 1. Idealized triode (a) and pentode (b) characteristics.

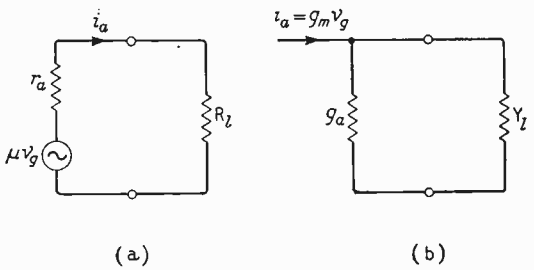

Fig. 2. Voltage (a) and current (b) generator equivalent circuits of the valve amplifier.

Valve Admittance Parameters.—The primal equation for a valve is

$$i_a = f(v_g, v_a)$$

This may be immediately developed into

$$\delta i_a = \frac{\partial i_a}{\partial v_g}\,\delta v_g + \frac{\partial i_a}{\partial v_a}\,\delta v_a$$

Both the partial differential coefficients have the dimensions of an admittance, hence the equation may be written

$$g_m v_g + g_a v_a = i_a$$

where the currents and voltages are all incremental: for our case we may say they represent the instantaneous values of the sinusoidal currents and voltages.

Conventional Development.—It is usual to develop the primal equation by specifying that a signal voltage be applied between the grid and cathode only, and that a load be placed in the anode circuit. The equation then becomes

$$g_m v_g - g_a (i_a R_l) = i_a$$

where $-i_a R_l$ is the back e.m.f. across the load. g_a is then inverted and expressed as a resistance ($r_a = 1/g_a$) and the equation easily resolves to

$$i_a = \frac{e_g g_m r_a}{r_a + R_l} = \frac{\mu e_g}{r_a + R_l}$$

where μ may or may not have a positive sign, according to the convention adopted.

The next step shows how this equation may be represented by the circuit shown in Fig. 2(a), where i_a is obviously the current flowing through the generator and load.

This, however, is only one way of interpreting the equation. Suppose we apply Norton's Theorem, as we did in the first half of this article, and transform the valve from a "constant-voltage generator" to a constant-current generator. We obtain the circuit shown in Fig. 2 (b).

In *this* circuit i_a is the current flowing in from the generator; it has a constant value for all loads from short circuit to open circuit; in the latter case it all flows out through g_a.

Nodal Development.—Returning now to the primal valve equation, we see that it has a nodal form since it gives current in terms of voltage multiplied by admittance. Since there are two voltages there must be two significant nodes and hence two equations, one for the input and one for the output. We may immediately write down the general set of nodal equations:—

$$Y_{11} V_1 + Y_{12} V_2 = I_1 \text{ (node 1, input)}$$
$$Y_{21} V_1 + Y_{22} V_2 = I_2 \text{ (node 2, output)}$$

Now a valve is an active network: it extracts unidirectional energy from the power supply unit and transforms it into alternating energy. Thus we would hardly expect its nodal equations to fall out exactly as for a passive network. The differences, however, are not large.

Fig. 3 shows the basic ideal valve amplifier (no load resistor and no grid resistor) with the input and output nodes N_1 and N_2 marked in. A cursory glance at this figure will show us that $V_1 = v_g$ and $V_2 = v_a$, but I hope we will not now fall into the trap of writing $I_2 = i_a$. I_2 is the current supplied from an external generator to node 2. In this case

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there is no such generator since we have specified one generator only, feeding a signal to the grid. I_2 is therefore zero. However, it is important to note that although I_2 is zero, this does *not* mean that no current flows into node 2 at all. Actually the anode current, i_a, flows from node 1 (the grid) to node 2 (the anode) and then to earth again, via g_a.

Now what of the coefficients Y_{21} and Y_{22} in the second nodal equation? Y_{21} corresponds to current flowing into node 2 (the anode) due to a voltage at node 1 (the grid). This, by definition, is g_m. Y_{22} is the admittance in the output circuit. For the case we are considering this, by definition, is g_a. In a practical amplifier Y_{22} would include all the admittances in the output circuit, i.e. the load resistor, stray capacities etc. The second nodal equation for a valve is thus

$$g_m V_1 + g_a V_2 = 0 \text{ (node 2)}$$

This is our primal equation in nodal form. We might have expected the current flowing into node 2, $g_m V_1$, to have a negative sign, so as to agree with our selected conventions. It must be remembered, however, that this current is itself negative, since increasing V_1 positively increases the flow of electrons or negative current, and a negative current flowing in a negative direction will have a positive sign.

What of the equation for node 1? The derivation of this will be quite straightforward. For the case where we have no grid resistor, and when we work in Class A1 (no grid current), I_1 must be zero. Hence, if I_1 is to be expressed in terms of V_1 and V_2, these must both be prefixed with a nought, which gives us

$$0V_1 + 0V_2 = I_1$$

This just means that the valve itself draws no current from the generator driving it. Looking in detail at the coefficients Y_{11} and Y_{12} in this equation, Y_{11} is the admittance in the input circuit. With no grid resistor this will be zero. In a practical amplifier, however, the grid admittance Y_g will appear in Y_{11} and then I_1 will have a definite value. Y_{12} corresponds to current flowing into node 1 (the grid) due to a voltage at node 2 (the anode). For the perfect valve we are considering Y_{12} must thus also be zero. (We will consider the practical case—"Miller Effect"—later.)

If we assemble our results for the ideal valve we obtain

$$0V_1 + 0V_2 = I_1 \text{ (node 1)}$$
$$g_m V_1 + g_a V_2 = 0 \text{ (node 2)}$$

These equations show clearly the differences between active and passive networks.

(1) In a passive network Y_{12} always has the same magnitude and sign as Y_{21}. In an active network this is not so. (Here $Y_{12} = 0$ and $Y_{21} = g_m$.)

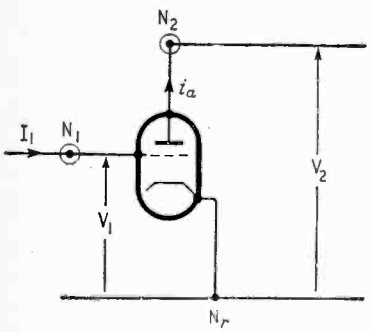
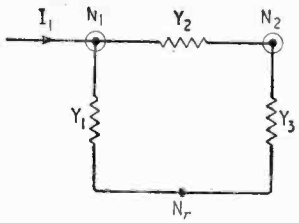


Fig. 3. Basic ideal valve amplifier.



$$(Y_1 + Y_2) V_1 - Y_2 V_2 = I_1$$
$$-Y_2 V_1 + (Y_2 + Y_3) V_2 = 0$$

Fig. 4. Simple two-node passive network with its associated nodal equations.

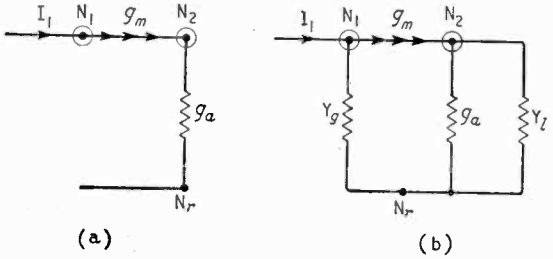


Fig. 5. Equivalent nodal circuits of a valve amplifier (a) in the ideal form of Fig. 3 and (b) with the addition of a grid admittance Y_g and load admittance Y_l.

(2) In a passive network the linking admittance joining nodes 1 and 2 appears in Y_{12} and Y_{21} prefixed with a negative sign, and also in Y_{11} and Y_{22} with its normal sign. (An easy example of this is shown in Fig. 4, together with its set of equations.) In the active network this is not so. (g_m appears in Y_{21} only, and is not included in the other three parameters.)

Hence a separate sign is necessary to indicate the unilateral admittances of an active network. We could make use of the appropriate arrow symbol for a one-way street, pointing from N_1 to N_2 say for Y_{21} and from N_2 to N_1 for Y_{12} in cases where it has a value other than zero (as in a transistor). The convention would be that where a unilateral admittance appears it is only shown once, in either Y_{12} or Y_{21}, according to the arrows, and with the sign shown. For example, the equivalent diagram of a valve only, in the ideal condition, would be as shown in Fig. 5(a). The valve with a grid admittance Y_g and a load admittance Y_l would have an equivalent circuit as in Fig. 5(b).

It only remains to state that any passive elements added to an active network behave as they normally do in a passive network, even if connected across nodes one and two, when they appear in all four parameters.

We can now proceed to apply these equations, and I think you will find this much easier than the derivation of the equations!

General Case of an Active Network.—We can now obtain some standard formulae for gain, input admittance and output admittance, which will apply to all such networks, passive or active, valve or transistor.

The general nodal equations for the case when there is no external generator connected to the output (node 2), i.e. with $I_2 = 0$, are

$$Y_{11} V_1 + Y_{12} V_2 = I_1$$
$$Y_{21} V_1 + Y_{22} V_2 = 0$$

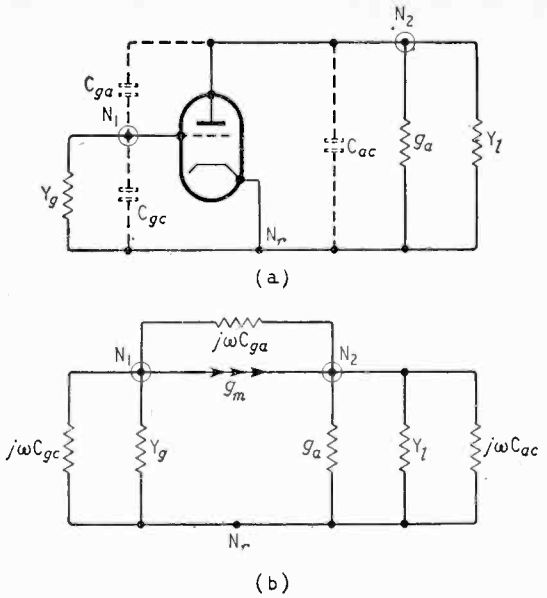


Fig. 6. Valve with interelectrode capacities (a) and its nodal equivalent circuit (b).

It can immediately be seen from the second equation that the voltage gain

$$\frac{V_2}{V_1} = -\frac{Y_{21}}{Y_{22}} = M_v$$

Similarly the short-circuited (output) current gain will be

$$\frac{I_2}{V_1} \times \frac{V_1}{I_1} = \frac{Y_{21}}{Y_{11}} = M_i$$

The input admittance of the network, which can include the load, may be found from the equations as follows. From the second equation $V_2 = -Y_{21} V_1 / Y_{22}$ and substituting this into the first equation gives

$$Y_{11} V_1 - \frac{Y_{12} Y_{21}}{Y_{22}} V_1 = I_1$$

Thus $Y_{in} = \frac{I_1}{V_1} = Y_{11} - \frac{Y_{12} Y_{21}}{Y_{22}} = Y_{11} + M_v Y_{12}$

Conversely, the " looking-back " admittance at the output will be

$$Y_o = Y_{22} - \frac{Y_{12} Y_{21}}{Y_{11}} = Y_{22} - M_i Y_{12}$$

From these equations we can see that the load only affects the source admittance, and vice versa, if both Y_{12} and Y_{21} have values (i.e. neither are zero).

Simple Valve Amplifier.—The nodal equations for the valve under ideal conditions are

$$0 V_1 + 0 V_2 = I_1$$
$$g_m V_1 + g_a V_2 = 0$$

The voltage gain $= -g_m/g_a = -g_m r_a = -\mu$.

The nodal equation brings out clearly to the new student the fact that the valve amplification factor is merely the ratio of two admittances.

Now take a simple amplifier, with anode load Y_l. Since the valve is being treated as a current generator the load will appear in parallel with the generator admittance. If we include the grid resistor $(1/Y_g)$ our equivalent diagram will be as in Fig. 5(b), and our equations will become

$$Y_g V_1 + 0 V_2 = I_1$$
$$g_m V_1 + (g_a + Y_l) V_2 = 0$$

The voltage gain

$$M_v = -\frac{Y_{21}}{Y_{22}} = \frac{-g_m}{g_a + Y_l}$$

Unfamiliar? Change the admittances to impedances and

$$M_v = \frac{-g_m}{\frac{1}{r_a} + \frac{1}{R_l}} = \frac{-g_m}{\frac{R_l + r_a}{R_l\ r_a}}$$
$$= \frac{-g_m r_a R_l}{R_l + r_a} = \frac{-\mu R_l}{R_l + r_a}$$

which is familiar to everyone—yet not as simple. If Y_l should be complex, say $g_l + jB_l$, then

$$M_v = \left|\frac{g_m}{\sqrt{(g_a + g_l)^2 + B_l^2}}\right| \underline{/180° - \theta}$$

where $\theta = \arctan \frac{B_l}{g_a + g_l}$

Calculation of Miller Effect.—Due to interelectrode capacitance a valve, particularly a triode, is not truly unilateral at high frequencies, but does transfer some energy from the output to the input, and so modify the input admittance of the valve. The basic circuit and its equivalent are shown in Fig. 6(a) and (b) and the pair of nodal equations will be

$$[Y_g + j\omega (C_{gc} + C_{ga})] V_1 - j\omega C_{ga} V_2 = I_1$$
$$[g_m - j\omega C_{ga}] V_1 +$$
$$[g_a + Y_l + j\omega(C_{ac} + C_{ga})] V_2 = 0$$

The voltage gain

$$M_v = -\frac{Y_{21}}{Y_{22}} = -\frac{g_m - j\omega C_{ga}}{g_a + Y_l + j\omega (C_{ac} + C_{ga})}$$

The input admittance

$$Y_{in} = Y_{11} + M_v Y_{12}$$
$$= Y_g + j\omega(C_{gc} + C_{ga}) - j\omega C_{ga}|M_v| \underline{/180° + \phi}$$
$$= Y_g + j\omega C_{gc} + \omega C_{ga}(1 \underline{/90°} + |M_v| \underline{/90° + \phi})$$

This is the normal equation for the input admittance of a triode amplifier at radio frequencies; we have found it, together with the gain, in a few lines of working. Other examples of valves working with grounded cathode can be solved in the same manner.

Grounded-Anode Stage (Cathode Follower).—Let us now examine the grounded-anode stage. Here, due to the valve being inverted, the nodal equations must be modified. The primal equation, $i_a = g_m v_g + g_a v_a$ always applies, whatever the configuration. Referring to Fig. 7 we see that $v_a = -V_2$, and since $v_{ac} = v_{ag} + v_{gc}$, then $v_{gc} = v_{ac} - v_{ag} = -V_2 - (-V_1)$. Hence $i_a = -g_m(V_2 - V_1) - g_a V_2$. Allowing for the reversed direction of i_a, the nodal equations then become

$$0 V_1 + 0 V_2 = I_1$$
$$-g_m V_1 + (g_m + g_a) V_2 = 0$$

These equations are easily remembered, whilst the procedure for finding the gain etc., is exactly as before. Let us draw the circuit of a typical cathode follower and its equivalent, and then write down the nodal equations. The circuits are shown in Fig. 8(a) and (b) and the nodal equations are

$$Y_g V_1 + 0 V_2 = I_1$$
$$-g_m V_1 + (g_m + g_a + Y_k) V_2 = 0$$

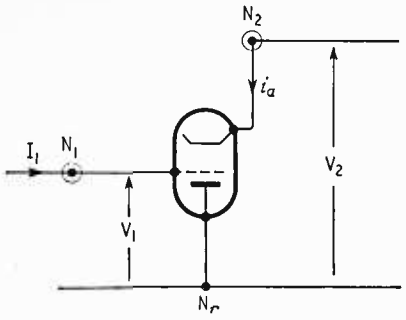


Fig. 7. Basic ideal grounded-anode valve (cathode follower).

The voltage gain

$$M_v = -\frac{Y_{21}}{Y_{22}} = \frac{g_m}{g_m + g_a + Y_k}$$

This is obviously less than one. Typical values may be, $g_m = 2.5$ milliamps per volt, $g_a = 100$ micromhos and $Y_k = 100$ micromhos. The gain is then 0.925.

If the gain equation is transformed into impedances we obtain for the voltage gain

$$M_v = \frac{\left(\frac{\mu}{1+\mu}\right) R_k}{\left(\frac{r_a}{1+\mu}\right) + R_k}$$

This is the familiar equation, which shows voltage negative feedback.

Since Y_{12} is zero, the input admittance is just Y_g and the output admittance $g_m + g_a + Y_k$. However, things become quite different if Y_g is connected between grid and cathode (i.e. between nodes 1 and 2). The input admittance then falls to about one-tenth of Y_g and the output admittance is now no longer independent of the input admittance. Why not work it out for yourself? There are some good notes by J. McG. Sowerby in the *Wireless World* for September, 1948.

The behaviour of the cathode follower at high frequencies can be studied by including the inter-electrode and other capacitances.

Grounded-Grid Amplifier.—Since the procedure followed is identical with that for the cathode follower, the explanation will be curtailed. Referring to Fig. 9 we see that $v_g = -V_1$ and $v_a = V_2 - V_1$. Substituting we find that $i_a = -(g_m + g_a)V_1 + g_a V_2$. Now I_1 must have the same magnitude as i_a (there being no grid current). Therefore it should have the same coefficients as i_a, but with the signs changed, since current flowing out of node 1 is positive, whereas the same current flowing into node 2 is negative. Hence our nodal equations are

$$(g_m + g_a)V_1 - g_a V_2 = I_1$$
$$-(g_m + g_a)V_1 + g_a V_2 = 0$$

A simple circuit and its equivalent are shown in Fig. 10(a) and (b). Its equations are

$$(Y_k + g_m + g_a)V_1 - g_a V_2 = I_1$$
$$-(g_m + g_a)V_1 + (g_a + Y_l)V_2 = 0$$

The voltage gain $= -\frac{Y_{21}}{Y_{22}} = \frac{g_m + g_a}{g_a + Y_l}$

If Y_l and g_m are much larger than g_a, this gain approximates to g_m/Y_l or $g_m Z_l$.

The input admittance will be $Y_{11} + M_v Y_{12}$ or approximately $Y_k + g_m$, for the same conditions as the gain.

Indefinite Admittance Matrix.—All the basic valve configurations have now been dealt with. We will conclude this section by giving a mnemonic to enable you to remember the three sets of equations.

First write down the admittance parameters of the common-cathode valve configuration in the position they normally occupy in the equations. We get

$$\begin{matrix} 0 & 0 \\ g_m & g_a \end{matrix}$$

Now add a third column (on the right) and a third row (underneath) in such a way as to make the sum of every column or row zero. Lastly mark the rows and columns G, A and C, as shown.

	G	A	C
G	0	0	0
A	g_m	g_a	$-(g_m + g_a)$
C	$-g_m$	$-g_a$	$(g_m + g_a)$

For grounded-cathode working strike out the third (C) row and column. This brings us back to where we started, viz.

$$\begin{matrix} 0 & 0 \\ g_m & g_a \end{matrix}$$

For grounded-anode working strike out the second (A) column and row, which gives

$$\begin{matrix} 0 & 0 \\ -g_m & (g_m + g_a) \end{matrix}$$

This agrees with the values already found.

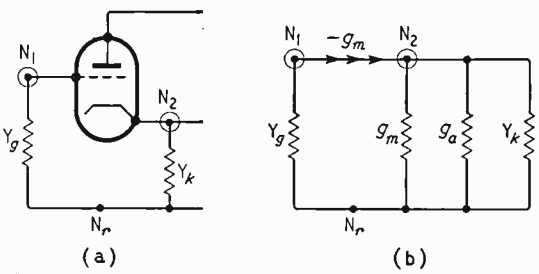


Fig. 8. Typical cathode-follower (a) and its nodal equivalent circuit (b).

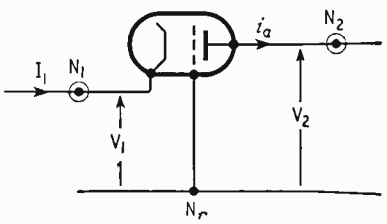


Fig. 9. Basic ideal grounded-grid valve.

Lastly, for grounded grid, we cross out the first (G) row and column to obtain

	A	C
A	g_a	$-(g_m + g_a)$
C	$-g_a$	$(g_m + g_a)$

This places the anode in the top left-hand corner, which is input, and the cathode in the bottom right-hand corner, or output. We therefore make a diagonal changeover of all four parameters to get

$$\begin{matrix} (g_m + g_a) & -g_a \\ -(g_m + g_a) & g_a \end{matrix}$$

This again agrees with the values previously found.

You may protest that these equations are easy enough to remember without this mnemonic; if so I would agree. The real reason they were brought in here was to show that the method gave the right

(*Continued on page 603*)

answers with a valve. We will soon use the same method to convert a common-emitter configuration transistor to common collector or common base. The real justification for this method lies in matrix theory, and is due to J. Shekel[1]. This subject, however, is outside the scope of the present article.

Transistor as an Active Network.—The transistor, like the thermionic valve, is an active two-node network and as such its manipulation and basic equations for gain and input and output admittance are the same as the valve. Once we have obtained the nodal equations for the transistor the rest is merely a repetition of what we did with the valve.

Derivation of Transistor Parameters.—Following common practice, we will first consider the transistor in common base. The transistor collector curves, shown in Fig. 11(a) strongly resemble the pentode anode characteristics shown in Fig. 1(b), with one subtle difference. Whereas each separate curve on the valve characteristic represents a certain grid *voltage*, on the transistor collector characteristic each curve represents a certain emitter *current*. This makes quite a difference to the resulting equations. We must now say

$$i_c = f(i_e, v_c)$$

Our other parameter, the emitter voltage, must then also be expressed in terms of the same variables.

Once again we get equations of the form

$$\delta v_e = \frac{\partial v_e}{\partial i_e}\,\delta i_e + \frac{\partial v_e}{\partial v_c}\,\delta v_c$$

$$\delta i_c = \frac{\partial i_c}{\partial i_e}\,\delta i_e + \frac{\partial i_c}{\partial v_c}\,\delta v_c$$

$\partial v_e/\partial i_e$ is dimensionally an impedance and we may replace it with r_{11}. Similarly $\partial i_c/\partial v_c$ is dimensionally a conductance and may be replaced by g_{22}. On the other hand $\partial v_e/\partial v_c$ is a mere ratio between two voltages, let us use μ_r for this, where the subscript means "reverse" (voltage fed back to input). In the same way $\partial i_c/\partial i_e$ is the forward current gain and its symbol is usually α.

Our set of equations thus becomes

$$r_{11} i_e + \mu_r v_c = v_e$$
$$\alpha i_e + g_{22} v_c = i_c$$

with the signs depending on the convention employed.

By the reasoning employed in the first article, r_{11} and α are measured with the output short circuited to a.c. whereas μ_r and g_{22} are measured with the input open circuited to a.c.

Now it happens that in matrix theory there is a set of equations of the form

$$H_{11} I_1 + H_{12} V_2 = V_1$$
$$H_{21} I_1 + H_{22} V_2 = I_2$$

which is of the same basic form as those we have just derived. Thus the next step was to substitute H_{11} for r_{11}, H_{12} for μ_r, H_{21} for α and H_{22} for g_{22}. It wasn't really necessary, but you must admit it looks good and is calculated to baffle the most pertinacious student. Indeed we have now reached a dead end and will have to transform these "hybrid" parameters (from the H and the mixed dimensions) into admittances, similar to the valve, if we wish to attack transistor problems without the aid of a course in memory training.

We can easily transform the H parameters into Y by the aid of simple algebra, but if the transistor manufacturers would quote these values it would save us the trouble.

[1] *Wireless Engineer*, Jan. 1954, p. 6.

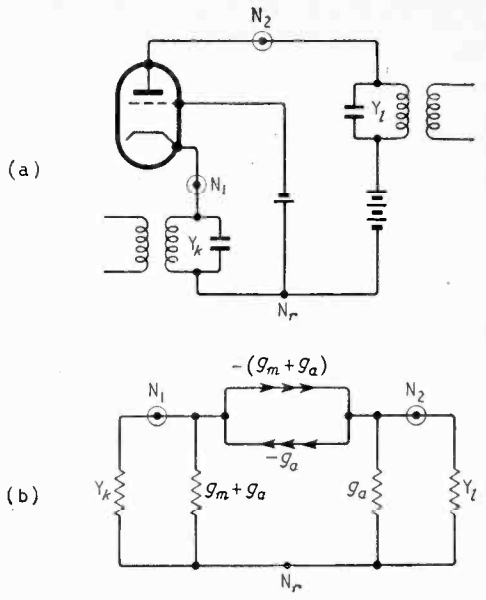


Fig. 10. Simple grounded-grid amplifier (a) and its nodal equivalent circuit (b).

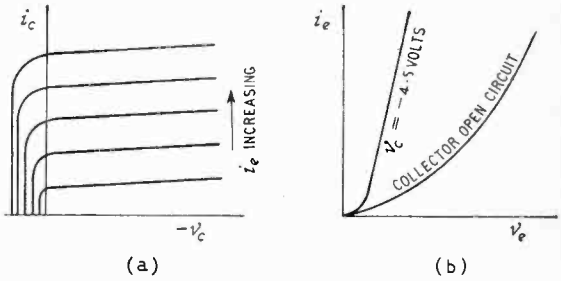


Fig. 11. Common-base characteristics of the transistor (a) at its output and (b) at its input.

From the first equation we can quickly obtain

$$I_1 = \frac{1}{H_{11}} V_1 - \frac{H_{12}}{H_{11}} V_2$$

Substituting this into the second equation we get

$$I_2 = \frac{H_{21}}{H_{11}} V_1 + \frac{|H|}{H_{11}} V_2$$

Where $|H| = H_{11} H_{22} - H_{12} H_{21}$

Hence

$$Y_{11} = \frac{I}{H_{11}}, Y_{12} = -\frac{H_{12}}{H_{11}}, Y_{21} = \frac{H_{21}}{H_{11}}, Y_{22} = \frac{|H|}{H_{11}}$$

Transistor manufacturers usually publish a set of H parameters for common-emitter, common-collector and common-base working—three sets—for each transistor.

It is common for teachers and lecturers to approach transistors from the common-base viewpoint, but in practice the common-emitter configuration is far more common. We will therefore give our example on the common-emitter configuration. Common-emitter parameters may be found in the same way as common base, and they are always given by transistor manufacturers. In any case it is always possible to transform from one configuration to another.

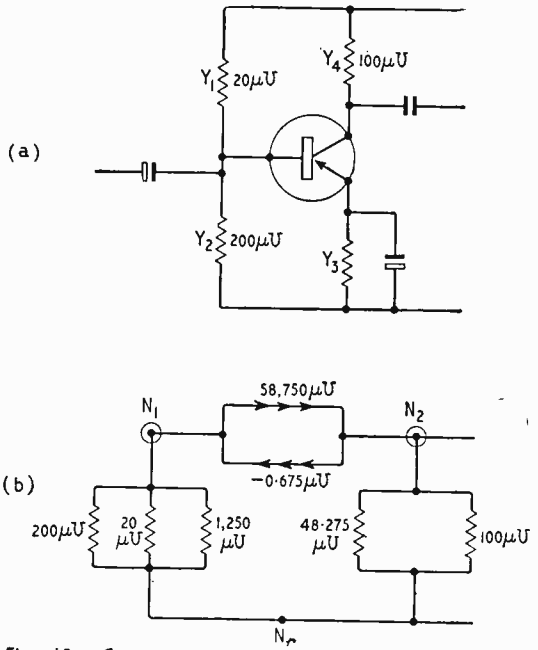


Fig. 12. Common-emitter transistor current amplifier (a) and its nodal equivalent circuit (b) (℧ ≡ mho).

Common-Emitter Transistor Amplifier.—Mullards give the hybrid parameters of their OC 71 transistor in common emitter as

$H_{11} = 800$ ohms, $H_{12} = 5.4 \times 10^{-4}$
$H_{21} = 47$, $H_{22} = 80 \times 10^{-6}$ mhos

The admittance parameters work out to

$Y_{11} = 1{,}250$, $Y_{12} = -0.675$ } all figures in
$Y_{21} = 58{,}750$, $Y_{22} = 48.275$ } micromhos

Consider the amplifier shown in Fig. 12(a).

A little consideration will show that both Y_1 and Y_2 are in parallel across the input, whilst Y_4 is obviously across the output. The equivalent circuit is then as in Fig. 12(b).

The voltage gain is still

$$M_v = -\frac{Y_{21}}{Y_{22}} = -\frac{58{,}750}{148.275} = -396$$

The current gain, with output short circuited to a.c.

$$M_i = \frac{Y_{21}}{Y_{11}} = \frac{58{,}750}{1{,}470} = 40$$

The input admittance

$$Y_{in} = Y_{11} - \frac{Y_{12}Y_{21}}{Y_{22}} = Y_{11} + M_v Y_{12} = 1{,}737\ \mu\text{mhos}$$

The "looking-back" admittance at the output

$$Y_o = Y_{22} - \frac{Y_{12}Y_{21}}{Y_{11}} = Y_{22} - M_i Y_{12} = 175.3\ \mu\text{mhos}$$

Perhaps you will agree that once the admittance parameters have been worked out, or obtained from manufacturer's data, the actual work involved in finding the gain, etc., is small.

Transistor in Common Collector and Common Base.—If one wishes to obtain the performance of a transistor in common collector (near equivalent to the cathode follower) or common base (equivalent of grounded grid), the admittance parameters for these configurations can easily be obtained from those of the grounded-emitter admittances, without recourse to the hybrid parameters again. We employ the indefinite admittance matrix, as we did for the valve, using a modification of the method devised by Shekel[2].

First write down the admittance parameters of the common-emitter configuration, in the positions which they normally occupy in the equations. Now add a third column (on the right) and a third row (underneath) in such a way as to make the sum of every column or row zero. Lastly mark the rows and columns, B, C and E. I have done it for the OC 71.

	B	C	E	
B	1,250	− 0.675	− 1,249.325	} all in
C	58,750	48.275	−58,798.275	} micromhos
E	−60,000	−47.600	60,047.6	

To obtain common-emitter parameters strike out the E row and column. (This brings us back to our starting point, of course.)

To obtain the common-collector parameters strike out the C row and column. This leaves

1,250 −1,249.325 } all in
−60,000 60,047.6 } micromhos

which are the admittance parameters for the OC 71 when used in grounded collector. They are used exactly as were the valve admittance parameters in the cathode follower.

For the common-base configuration we strike out the first (B) row and column. This gives the collector in the top left-hand corner, which is input, and the emitter in the bottom right corner, or output: our transistor is connected the wrong way round. It is therefore necessary to make a diagonal switch of all four parameters which gives

60,047.6 −47.600 } all in
−58,798.275 48.275 } micromhos

Again, these common-base parameters may be used to find gain, input admittance and output admittance exactly as shown for the common emitter, or for that matter, the valve.

Conclusion and the Shape of Things to Come.—This then is nodal analysis as applied to passive and active networks. The basic procedure is the same for passive, valve or transistor circuits, which should be of considerable help to students. Only a few examples of its use are shown, it really is a powerful method: however, it does not supersede mesh analysis, but is complementary to it.

And where do we go from here? The next step would be a study of four-terminal networks, using matrices, assisted by determinants. If you should be interested in the transient case, nodal analysis may still be very helpful, in conjunction with Laplace transforms, and will tell you whether a network is stable or unstable, and what sort of response (current) will occur as a result of an externally applied stimulus (which is commonly non-sinusoidal)[3].

However, leave these latest methods until you are quite familiar with mesh and nodal analysis: between them they will take you a long way, especially the latter!

This article is published with the permission of Lt. Col. J. Harris, C.O., 3 Trg. Bn., R.E.M.E. Arborfield.

[2] *Proc. I.R.E.*, Nov. 1952, p. 1493.
[3] See, for example, "Linear Feedback Analysis", by J. G. Thomason (Pergamon Press).

Camera Remote Control

USED IN B.B.C. REPORTING STUDIOS

By G. W. H. LARKBY*

In recent years the stability of vidicon cameras has improved to the degree that it is now possible to use them without the attention of technical operators. The first example of the use of an unattended camera in this fashion was, in fact, in the B.B.C.'s Parliamentary Reporting Studio at Westminster which was put into service about a year ago.

This studio is as simple as it is possible to conceive a television studio to be, consisting of a small room furnished with a table and chair, lights, microphone and a single television camera in a fixed position. The studio is brought into action by remote control from the Television News Studio at Alexandra Palace where the received signal is "mixed" into the programme. The operational success of this facility, simple as it is, stimulated a demand to be able to control the main positional functions of the remote camera in order to give variety to the presentation. In turn, the development of the apparatus for this positional control has led to the provision of a facility whereby the camera can be made to take up any one of a number of pre-set "shots" by the operation of a push-button switch, which may, if desired, be operated by the "subject" himself.

The camera functions which require to be controlled are horizontal angle (pan), vertical angle (tilt), angle of view (focal length of lens), camera focus and lens aperture. In order to avoid a hiatus in the picture while changing the focal length of the lens, advantage can be taken of a zoom lens.

As a field experiment, a vidicon camera has been fitted with a zoom lens and is installed in the B.B.C.'s studio in All Souls Hall, near Broadcasting House, and the camera can be controlled in all its main functions, either from the local control room or from the control room at Alexandra Palace, some seven miles away.

The camera is a standard vidicon, of a type in general use in interview studios where it is normally fitted with a four-lens turret. For the purpose of this experiment, the turret was removed and replaced by a cast plate on which is mounted the zoom lens together with the motor mechanisms for the zoom, focus and iris movements.

The servo system employed is shown in Fig. 1. The two potentiometers, A and B, form a bridge circuit of which the potential difference, at d.c., between points A and B, is fed to a modulator, which detects the potential difference between these two points and provides a correcting signal which, in turn, operates a motor so that the two points are brought as nearly as possible to the same potential. The modulator circuit employed is the well-known "ring" connection of four diodes to which, in addition to the d.c. control voltage, a constant 50 c/s e.m.f. is also connected. In order to keep harmonics in the output voltage to a reasonably low level the amplitude of the 50 c/s applied to the modulator is relatively low. It can be seen from the symmetry of the circuit that at balance, i.e., when A and B are at the same potential, there will be no 50 c/s output from the bridge into the control amplifier. On the other hand, when potentiometer A is moved, say to give a current flowing in the direction from B to A, diodes M1 and M3 conduct, causing the 50 c/s e.m.f. in transformer T1 to send a current through the centre-tapped winding of the transformer T2, producing an output in a particular phase. Movement of potentiometer A in the other direction, so as to cause a current to flow from A to B, makes diodes M2 and M4 conduct and, as compared with the previous condition, reverses the connection of the e.m.f. in transformer T1 to the terminals of transformer T2. Thus the phase of the output of the voltage from T2 changes by 180° as the direction of current between A and B reverses. Accordingly, the motor can run in either direction, depending upon the position of potentiometer B relative to potentiometer A. The a.c. output from the bridge is amplified and drives the servo control motor, which will always attempt to keep the bridge

* B.B.C. Designs Department.

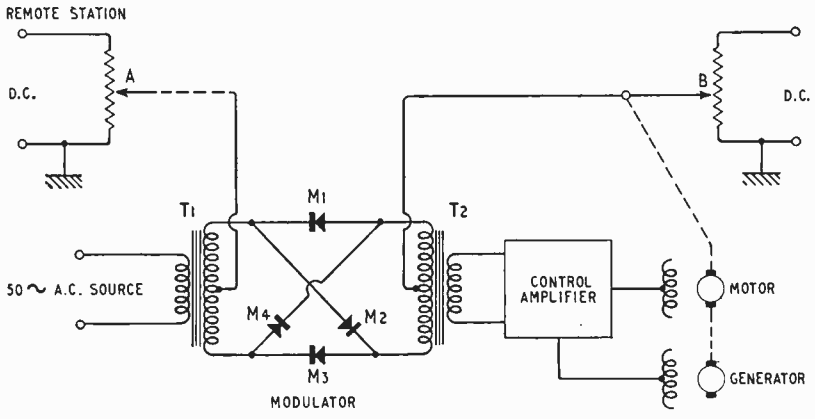


Fig. 1. Servo system schematic used for the remote control of a television camera.

Fig. 2. Servo motors, zoom lens, etc., mounted in place of the normal four-lens turret. These are enclosed in a cover which also forms a lens hood.

in balance. Thus, any movement of the control knob results in an equal movement of the controlled potentiometers as the motor drives the bridge into balance. Coupled to the motor shaft is a generator which produces an output of voltage proportional to the speed which is fed into the servo amplifier and so adjusted as to make the whole system critically damped. The action is very nearly dead beat giving the operator the impression that the knob is directly coupled to the mechanism which it operates and he has little or no feeling that it may well be many miles away.

The use of d.c. for the control current has the advantage that for short distances, say of the order of 10 miles, low quality circuits may be used. The system as installed between Alexandra Palace and All Souls Studio makes use of phantom circuits superimposed on existing speech and music circuits. For longer distances on which a d.c. loop is not available, it would be necessary to translate the control signals to audio frequencies, at which they can be conveniently transmitted.

The control amplifiers are four identical transistorized units capable of giving a continuous output of 20 watts each. They are driven from a stabilized 24-volt power supply. The amplifiers are straightforward audio amplifiers with emitter follower driven Class B output stages, the transistors being OC71, OC71, OC72+OC72 driving 2N268+2N268. There are two controls, i.e., gain and velocity feedback, thus allowing the performance of any function to be varied at will.

The lens fitted has a minimum focus of 4 feet with a maximum aperture of f/2.8. The movement of the knurled operating rings required to go from minimum to maximum of all three functions of the lens is approximately 180°, and the preliminary design called for an operational time of 5 seconds end to end. This sets the reduction gear ratio for the servo motor, the stalled torque necessary at motor shaft being sufficient to overcome the friction of the mechanism. In view of the experimental nature of this camera only two positional servos were used on the lens, i.e., focus and zoom. The iris is controlled by a non-servo type of small reversible motor of low torque, end stops being used to limit travel. The servo balance potentiometers are mounted on the penultimate drive shaft; the final drive to the lens is by neoprene toothed timing belts. These belts have built-in flexible steel wires which prevent stretch, the teeth giving positive drive so that a minimum of side loading is required and they are silent in operation.

All the connections to the motors, etc., are brought out to a multi-way plug on the side of the plate. A cover with acoustic damping fits over the whole assembly and also operates as a lens hood.

The camera and lens assembly is mounted on a panning tilt head which has a tilting centre above the camera mounting platform so that the centre of gravity of the camera can be placed at this point, thereby making the whole assembly inherently balanced. The camera tilt mechanism consists of a sector of a circle whose centre is above the camera mounting surface. Gear teeth are cut in the curved underside of this sector and mesh with a transverse driving shaft. This mechanism can be seen in Fig. 2.

A servo motor is fitted to both pan and tilt mechanisms. The error detector in the tilt servo is a carbon track potentiometer geared to the transverse shaft, but that in the pan is a three-turn potentiometer to give adequate resolution. Velocity feedback is achieved by using a generator on the same shaft as the motor, as in the focus and zoom unit.

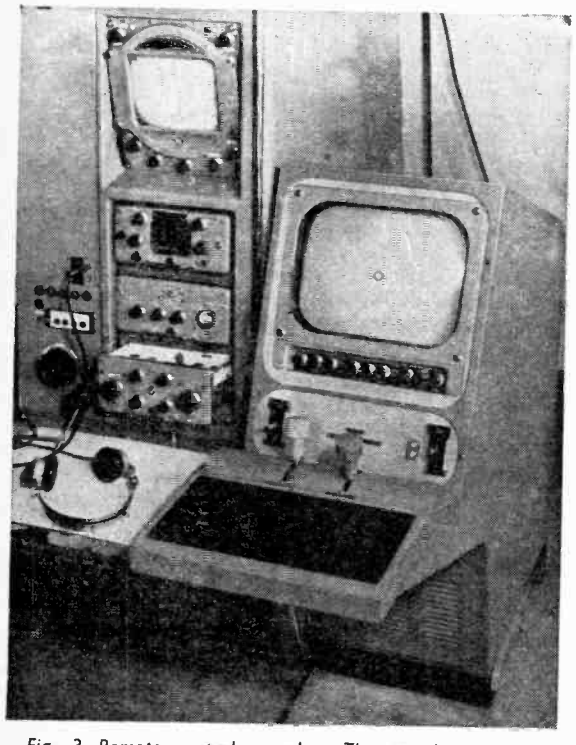


Fig. 3. Remote control console. The two large knobs control focus and zoom (left) and tilt and pan (right).

The pan motion uses an 8mm roller chain with a spring-loaded jockey pulley. In this case the driven chain wheel is fixed to the tripod head and the motor and driving pulley drive themselves round the head carrying the camera with them. The use of this method permits a change of gear ratio to be used without the use of large, expensive, special gears.

For continuous operation of the camera controls at the remote point, the operator sits at a console on the front of which are two knobs; each of these is moved in two modes: (a) rotation, (b) fore and aft like a lever. On the right-hand knob the rotation corresponds to pan and the fore and aft motion to tilt; on the left-hand knob the rotation corresponds to focus and the fore and aft to zoom (see Fig. 3). With a little practice, by the use of both hands the operator can control all four functions of the camera smoothly and comfortably.

It was soon apparent that to give smooth control, some form of damping on the motion is required, and this is provided by discs immersed in a silicone fluid rotating in a close-fitting chamber. The physical operation of each of these controls turns a potentiometer which forms part of the bridge of the appropriate servo mechanism.

Because the setting of any of the camera functions can be represented by the position of a potentiometer, by arranging to switch to groups of potentiometers, it is possible to give the camera a number of pre-set "shots." For example, Shot No. 1 might consist of a general view showing two people in conversation, Shot No. 2 would then be a close-up of the interviewer and Shot No. 3, perhaps, a close-up of the person being interviewed. On the operation of a push button, the camera can

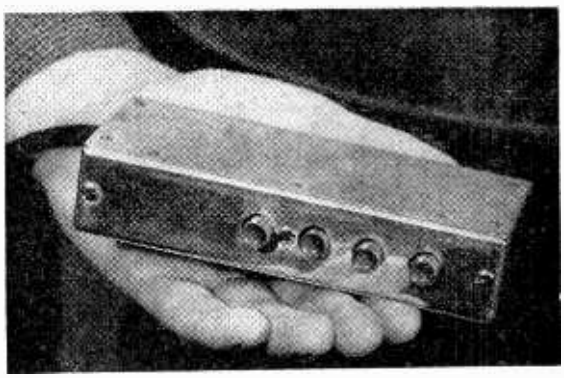


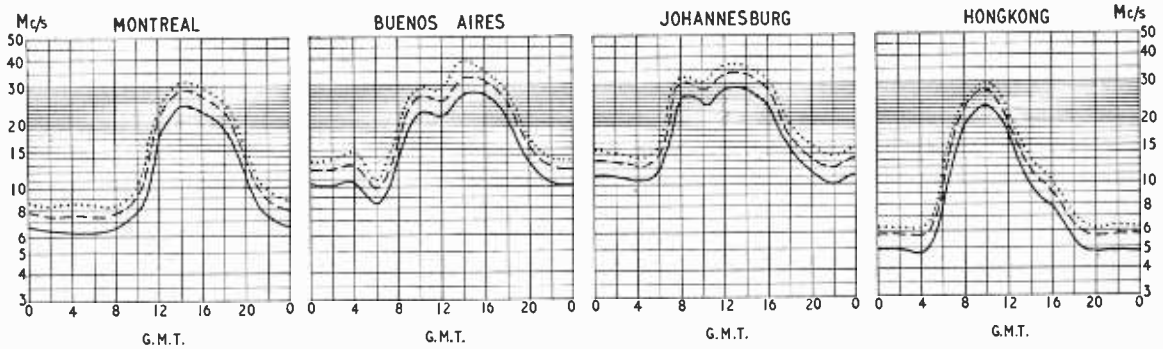
Fig. 4. "Shot-box" for the control of a camera by an interviewer.

be made to take up any of these shots at will. This leads to the possibility in studios where the programme is of a pre-set nature of using say, two remotely controlled cameras which look in turn at the appropriate "shots" under the control of the vision operators in the control room without having to have studio cameramen at all.

To pre-set any particular shot, it is only necessary to adjust the corresponding potentiometers for pan, tilt, focus and zoom, there being a group of four such potentiometers for each shot required. On the experimental camera the four positions on the "shot-box" control have proved adequate and useful. Visitors to one of the B.B.C. stands at the Earls Court Radio Show had the opportunity of manipulating a camera in this manner.

SHORT-WAVE CONDITIONS

Prediction for December



THE full-line curves indicate the highest frequencies likely to be usable at any time of the day or night for reliable communications over four long-distance paths from this country during December.

Broken-line curves give the highest frequencies that will sustain a partial service throughout the same period.

LETTERS TO THE EDITOR

The Editor does not necessarily endorse the opinions expressed by his correspondents

Transistorized Wien Bridge Oscillator

ON PAGE 390 of the August issue Mr. Butler says, "There is little point in using RC oscillators at frequencies much higher than 100kc/s, since it is simpler and cheaper to use switched tuned circuits."

Perhaps Mr. Butler would care to expand on this statement, since (1) there is some merit in being able to have sweep or continuous tuning. The usual Wien network oscillator has a continuous 10:1 frequency sweep, and this is not normally achieved in an LC tuned system and, (2) there are several RC oscillators commercially available extending beyond 100 kc/s.

Dorking, Surrey. D. J. COLLINS

The author replies:

I AGREE with Mr. D. J. Collins that a normal LC oscillator will not cover the 10:1 frequency range of an RC oscillator and that there are occasions when this wide coverage is of value in experimental work. Nevertheless the chief merit of the RC oscillator lies in the lower frequency part of the spectrum where LC oscillators require large and inconvenient tuning elements. At higher frequencies LC oscillators with continuously variable tuning elements have these advantages:—

(a) Low distortion due to the use of high Q components.

(b) High efficiency as compared with RC oscillators.

(c) Satisfactory operation from low voltage unregulated power supplies.

(d) High stability of frequency can be obtained in a simple way, e.g., by the use of capacitors having a negative temperature coefficient to offset the positive coefficient of the associated inductance.

(e) Distortionless amplitude control is easy to apply.

(f) Pulsed or modulated operation is possible.

(g) For a given scale length, the frequency of an LC oscillator covering a 3:1 range can be read more accurately than that of an RC oscillator covering a 10:1 range.

As stated in my paper, there is no difficulty in adding an extra range covering up to 200 kc/s if this is required. For distortionless operation at such high frequencies it is desirable to use v.h.f. transistors. This is because of difficulties due to hole-storage effects in transistors which have relatively low alpha cut-off frequencies. Moreover, v.h.f. transistors have a much lower collector capacitance. This parameter is dependent on temperature and on the collector voltage and is responsible for a variable amplifier phase shift which affects the frequency.

Mr. Alan Carpenter's fixed frequency 100 c/s oscillator (October issue) embodies some interesting design features and is outstandingly good in respect of frequency stability. At this low frequency, variation of transistor characteristics (like input and output capacitance) can be swamped by the much larger capacitances in the bridge elements. Even so, to achieve a stability better than 1 part in 1,000 is an excellent result.

My only criticism of the circuit is perhaps a trivial one. It concerns the method used for amplitude stabilization. As Mr. Carpenter states, the low heater resistance of the indirectly-heated thermistor shunts the emitter load of V3 and absorbs considerable signal power, at the same time introducing a rather long time constant into the control circuit operation. Although a 100μF capacitor is used in the feedback circuit there is a phase shift of about 10 degrees in the feedback voltage due to the associated 100-ohm heater element. In my experience, the actual capacitance of large electrolytics is sometimes well below the nominal value and it tends to vary with time and temperature. This would cause minor frequency fluctuations in the oscillator output of the kind Mr. Carpenter has mentioned. I am almost certain that the use of an R_{53} or, perhaps, better, an R_{14}, directly heated thermistor would cure this trouble and also give a more effective control of amplitude.

There is, however, an entirely different way of using an indirectly heated thermistor for control purposes if the long time constant is acceptable. It involves the use of an extra transistor stage as a Class B amplifier in which the thermistor heater forms the collector load. A suggested circuit is shown in Fig. 1 in which V3 is the last stage of Mr. Carpenter's amplifier and V4 is the power amplifier stage used to energize the thermistor heater. The virtue of this arrangement is that V4 is completely outside the main amplifier and feedback loop.

The function of V4 is merely to supply heater power proportional to the main oscillator output power. A Class B amplifier is suggested because in this case there is no initial heating of the thermistor by a standing collector current in V4. Use of a Class C connection might be still better, for then there would be no thermistor heating until the oscillator output reached a definite threshold level sufficient to overcome the initial reverse base bias of V4. Where low distortion is important it is just possible that the non-linear input impedance of V4 might prove objectionable but this effect could be minimized by including a moderately high series resistance in the base circuit of V4.

When fixed frequency operation of an oscillator is required there is a great deal to be said in favour of

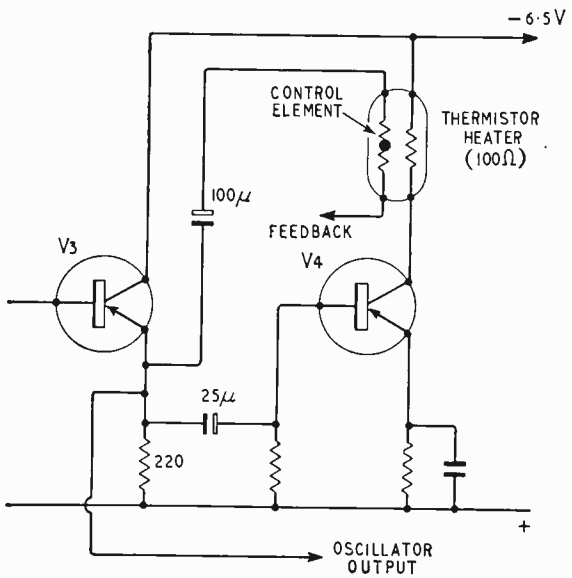
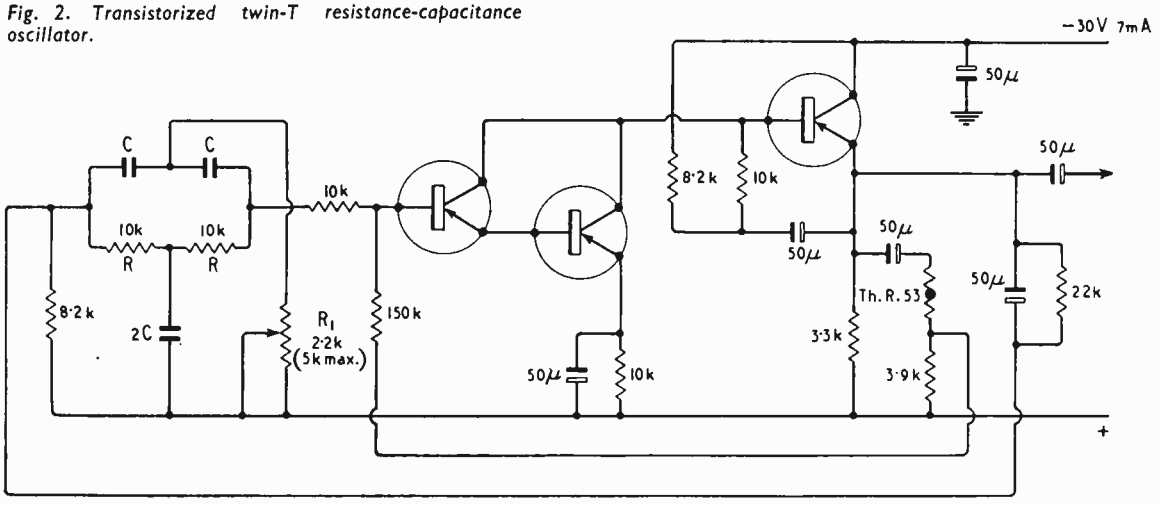


Fig. 1. Use of separate power amplifier for thermistor heater.

Fig. 2. Transistorized twin-T resistance-capacitance oscillator.



the twin-T RC circuit. This is in effect an equivalent of the Wien bridge which has a common input and output terminal. Reference (2) of my original article concerns a valve oscillator of this type, described by A. R. Bailey. The writer has developed a transistor version of Bailey's circuit, shown in Fig. 2. Space limitations preclude a full description of this arrangement but its salient features are the same as for the valve-operated version. Due to the use of high amplifier gain and a large amount of negative feedback the performance is outstanding in respect of low distortion and high frequency stability. For variable frequency operation the circuit is less attractive since it calls for the use of three ganged variable resistances one of which differs in value from the other two. Coarse changes of frequency are made by changing the capacitors C, C and 2C shown on the diagram. Mr. Carpenter may find the circuit useful for his timing standard. Regarding the super-alpha circuit used in my two designs, readers may care to note a brief reference to this compound-connected pair in the book "Transistor Circuit Engineering," (pp. 131-133), edited by R. F. Shea and published by Wiley.

In conclusion it may be of interest to mention a few points concerning the performance of the original Wien bridge oscillator. As regards its output level, measurements made on a version using a Standard Telephones Type R_{14} thermistor as TH.2 and a Type A as TH.1 show that the output is exactly the same over the two low-frequency ranges. On the highest frequency range this remains so up to a frequency of 13 kc/s. Between 13 and 20 kc/s the output falls slowly, dropping by 4 per cent (about one third of a decibel) at the highest frequency. Harmonic distortion is 1.2 per cent for 1 volt output at 1000 c/s.

There is a small change of frequency if a reactive load is connected across the output terminals. To remove this it would be necessary to use an emitter follower as a final output stage. Another OC 72 would be suitable for use in this position.

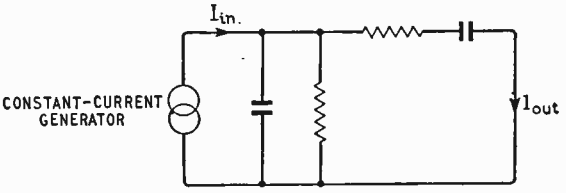
Finally, an earlier letter from Messrs. Evans and Williams, to which I replied in the October issue of *Wireless World*, cast some doubt on the performance of the super-alpha circuit at temperatures in excess of 30°C. This point has been checked by the crude expedient of holding a hot soldering iron near the casing of the first transistor V1 until it became uncomfortably hot to touch. Under these circumstances the total supply current dropped by about 10 per cent (due to the use of three d.c. coupled stages) but there was no noticeable change in the output level of waveform and only an insignificant change in frequency. No trouble from this source need be anticipated, using germanium transistors, at normal room temperatures. For use at very high temperatures it might be desirable to use silicon devices in this or any other comparable circuit.

Cheltenham. F. BUTLER

THERE is an alternative method of using RC tuning networks which avoids the difficulties arising from the low input impedance of a transistor which were pointed out by Mr. Butler in the August issue. It is to connect the networks as current attenuators rather than voltage attenuators. (See D. E. Hooper and H. E. Jackets, "Current Derived Resistance Capacitance Oscillators using Junction Transistors," *Electronic Engineering*, August 1956.)

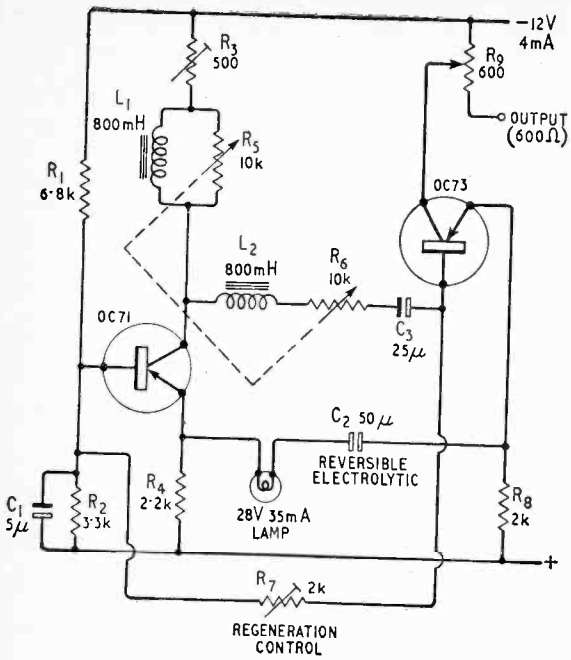
To operate a Wien type network in this way, an input *current* is applied to what are normally the output terminals, and an output current is taken from what are normally the input terminals. The frequency at which there is no phase shift is unaltered, and the current attenuation is the same as the voltage attenuation of the usual connection.

When the network is used in this way, the input



current must be supplied by a high-impedance source, such as a common-base transistor, and the output current must be supplied to a low-impedance load: again, a common-base transistor is indicated, though a common-emitter stage can be made to serve. Under these conditions, the effect of the maintaining amplifier on the frequency of oscillation is small, just as it is in voltage-operated circuits when the input voltage source has a low impedance and the output voltage is supplied to a high-impedance load.

A difficulty of current operation is that the resistance element of the parallel arm forms the d.c. collector load of a transistor. The value of resistance which can be used is then limited by considerations of supply voltage. This problem can, however, be avoided by using an RL network instead of an RC network. The collector current then flows through an inductor, as shown in the diagram, and there is only a small voltage drop. With resistances and inductances of equal value the frequency of oscillation is $R/2\pi L$. A danger in RL circuits is that the self-resonance of the chokes might provoke oscilla-



tion at the wrong frequency. In general, the risk can be reduced by making R as small as possible. When this is done, the resistance of the load, which comes in series with one of the R's, may not be negligible at the low-frequency end of a tuning range. It will affect both the frequency and the attenuation. One method of compensation is to add an extra resistance to the parallel arm (R_3 in the diagram). This trick is particularly useful in lamp-stabilized circuits, where variations in network attenuation are apt to have a bigger effect on the amplitude of oscillation than in thermistor-stabilized circuits.

The circuit shown is that of a "lash-up" constructed to see how and RL oscillator behaves in practice. It is not put forward as a proper design though, in fact, it exhibited reasonably good waveform and amplitude stability over the tuning range 100c/s—2kc/s.

Croydon. G. W. SHORT

FURTHER to the recent correspondence on transistorized Wien bridge oscillators, the accompanying circuit may be of interest.

By the use of n-p-n and p-n-p transistors in the amplifier it is possible to maintain correct bias conditions very easily, merely by biasing the first stage directly and the last stage by means of negative feedback.

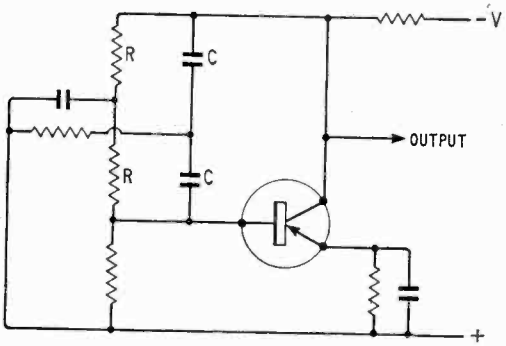
The optimum bias voltage at the point A is clearly half the supply potential and that at point B one-sixth, since the attenuation through the bridge is three times. R_7 and R_8 bias point B; R_1 and R_2 supply one-third of the amplifier output d.c. potential (i.e., one-sixth of the supply potential) as negative feedback to the emitter of the first transistor. The small potentials developed across R_4 and R_6 do not materially affect the biasing arrangements. With this arrangement R_5 and R_6 can be 100kΩ if desired

The association of a p-n-p and a n-p-n transistor for the second pair provides for handling a wide variation in load impedance without output amplitude variation.

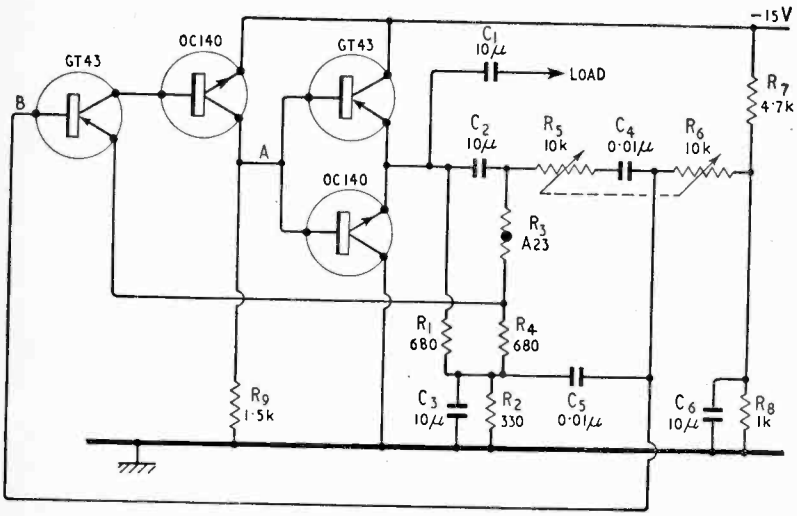
As shown the circuit will oscillate from 2 to 20kc/s. For supply potential variation from 13 to 22 volts, or with the load impedance varying from ∞ to 100 ohms, there is negligible waveform distortion, or variation in output amplitude and frequency.

Chertsey. W. R. NAYLAND, A. V. Roe and Co., Ltd.

I FEEL that Mr. Carpenter (October issue) has chosen a circuit which is not really suitable for a time standard. In the first place three active elements are used to pro-



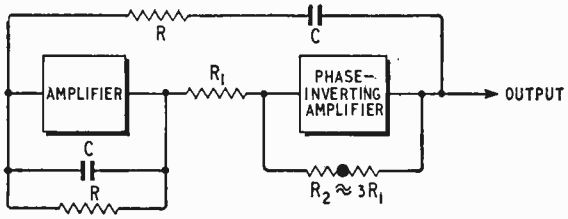
duce the necessary loop gain and phase shift to maintain oscillation; these are three items of variation and trouble. Secondly, the symmetrical case of the Wien bridge has poor selectivity and a strong dislike to a shunt impedance across the parallel RC in the network. However, the effect of this shunt impedance and the changing circuit parameters may be considerably offset by the introduction of the virtual earth system shown in the block diagram.



This refinement is still insufficient if a constant amplitude of output is required. Of course, this is due in the main to the thermistor.

With the preceding arguments I have been endeavouring to pave the way for a simple oscillating circuit briefly outlined in a paper in the section of the Proceedings of the I.E.E., at the Convention held on 25th May, 1959, and entitled "Discussion on Application: Linear Amplification and Oscillators." This oscillator consists of only one transistor and a selective network taking the form of the well-known parallel-T network.

(*Continued on page* 611)



When this oscillator was subjected to temperature variation of 20°-80°C., it is stated that the frequency shifted by less than 0.1% and the output change was less than 1%.

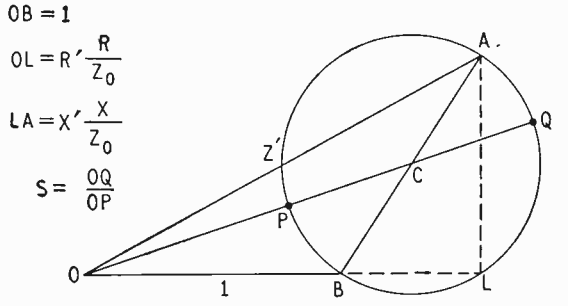
From these details it will be realized that the circuit has at least equalled the performance of the Wien bridge oscillator with considerable saving in component cost and greater reliability.

W. WOODMAN,
Nash & Thompson, Ltd.

Tolworth, Surrey.

Standing Wave Ratio

IN your June issue Mr. J. E. Robson describes a method of calculating the s.w.r. with the help of a quadratic



equation which on the face of it, appears to be frightening. Technicians possessing a pair of compass and a foot rule may find the following geometrical method much more instructional and useful in practical problems.

After normalizing the terminating impedance to $Z' = (R + jX)/Z_0$ a line OB equal to a unity is drawn to represent the normalized characteristic impedance. The line OA is then drawn to represent the normalized terminating impedance Z' with OB as the unity of scale. With AB as diameter the "reflection" circle is drawn as shown. Finally, O is joined to the centre of C of this circle, cutting the latter at P and Q. The s.w.r. is then given by

$$S = \frac{OQ}{OP}$$

This can easily be proved and, if required, Mr. Robson's equation for S obtained from the above construction without resort to complex variables and co-ordinate geometry.

Calcutta.

Q. C. GUPTA

Signal-flow Diagrams

IN the November issue S. R. Deards asks Thomas Roddam to try to justify the use of "signal-flow method" diagrams as superior to other methods. Thomas Roddam gracefully declines.

I would like to draw their attention to a book called "Introduction to Electronic Analog Computers" (Prentice Hall), signal-flow methods are described in application to computers, but it states that this method is useful not so much for *analysis*, as S. R. Deards thinks is its prime function, but for *synthesis*. It goes on to state that usually there is just not one good way, but several and this method allows one to decide which will suit the requirements. Where in the previous sentence I have used the word way, this applies to design, not s.f. methods.

Liverpool.

H. BAYLISS

PLEASE get it in your noddle
That matrix was *nodal*, not model.

THOMAS RODDAM

[We apologize to Thomas Roddam for the unlucky misspelling in line 13, right-hand column of page 562 of the previous issue. —ED.]

INDUSTRIAL GROUPS—3

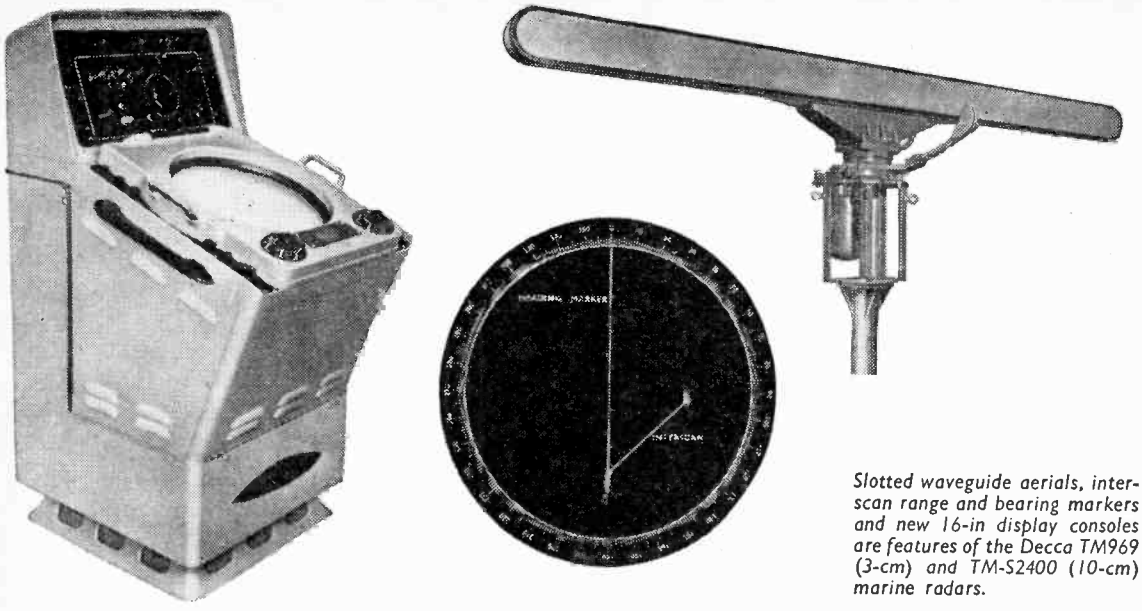
TWO or three times within the last few months the initials E.M.I. have been in the news because of take-overs or rumours of takeovers by the Group, whose latest acquisition is Ardente and its subsidiary Ardente Acoustic Laboratories for the sum of over £600,000.

Electric and Musical Industries, Ltd., was formed in 1931 to merge the interests of the Gramophone Co. and Columbia Graphophone Co., and today the Group embraces nearly 50 companies in this country and abroad. Among the trade names used by the Group are His Master's Voice and Marconiphone (both also used under licence for certain products by the Thorn Group), Capitol, Columbia, Parlophone, M.G.M., Mercury, Emarcy and, of course, many beginning with "Emi."

The Group's interests in the radio and electronics field range from sound and television broadcasting transmitters and ancillary equipment and electronic computers to domestic receivers and sound-reproducing equipment. In the latter field the Group markets the Emisonic Orthotone products jointly with Clarke & Smith, of Wallington, Surrey.

The following companies are within the group which during the last financial year made a profit of £5,348,000 —some £400,000 more than the previous year's figure:—

Alpha Accessories
Ardente
Ardente Acoustic Laboratories
Capitol Records Inc.
Columbia Graphophone Co.
Columbia Graphophone Co. of Greece
Comercial del Gramofono Odeon, S.A., Spain
Compania del Gramofono Odeon, S.A.E., Spain
Davey & Moore
Electric & Musical Industries
Electric & Musical Industries (China)
Electric & Musical Industries (Ireland)
Electrola G.m.b.H., Germany
E.M.I.-Cossor Electronics
E.M.I. Electronics
E.M.I. Records
E.M.I. Sales & Service
E.M.I. (South Africa)
E.M.I. Suppliers (Sud America)
EMIAG. Verkaufs A.G. der E.M.I., Switzerland
Gramofon Limitet Sirketi, Turkey
Gramophone Co.
Gramophone Co., Pakistan
His Master's Voice (N.Z.)
Home Maintenance
Imudico A/S, Denmark
Industrias Electricas y Musicales Odeon, S.A., Argentine
Industrias Electricas y Musicales Odeon, S.A., Chile
Industrias Electricas e Musicais Fabrica Odeon, S.A., Brazil
La Voce del Padrone-Columbia-Marconiphone S.p.A., Italy
Les Editions et Productions Musicales Pathe-Marconi, S.A., France
Lindstroem, Carl, G.m.b.H., Germany
Marconiphone Co.
Morphy-Richards
Morphy-Richards (Astral)
Morphy-Richards (Sales & Services)
Musica Argentina e Internacional, S.R.L.
Nordisk Beka Record A/S, Denmark
Oesterreichische Columbia Graphophone G.m.b.H., Austria
Parlophone Co.
S.A. Gramophone N.V., Belgium
Skandinavisk Grammophon A/S, Denmark
Skandinaviska Grammophon A/B, Sweden
Skandinavisk Odeon A/S, Denmark
Skandinaviska Odeon A/B, Sweden
Ardmore & Beechwood (Belgique) S.A.
Ardmore & Beechwood (S. Africa)
Les Industries Musicales et Electriques Pathe-Marconi, France



Slotted waveguide aerials, interscan range and bearing markers and new 16-in display consoles are features of the Decca TM969 (3-cm) and TM-S2400 (10-cm) marine radars.

NEW DECCA RADARS

ANALYSIS by Decca of more than 350 cases of collision at sea during the past five years has shown that more than 95% occur in congested shipping lanes and in pilotage waters, and the conclusion is drawn that the possession of radar is not in itself a guarantee of safety. Simple radar systems must be supplemented by facilities which will reduce the time and effort necessary for the interpretation of target movements on the p.p.i. display. A major step forward was taken with the introduction by Decca in 1956 of True Motion displays in which returns from buoys and coastlines remained stationary while "own ship" and other vessels under way were shown by moving spots leaving persistence trails to show their true motion. Even so the officers of the watch are often hard pressed in keeping under observation the changes of range and bearing of all the vessels in the vicinity which at any time might change to potential collision courses.

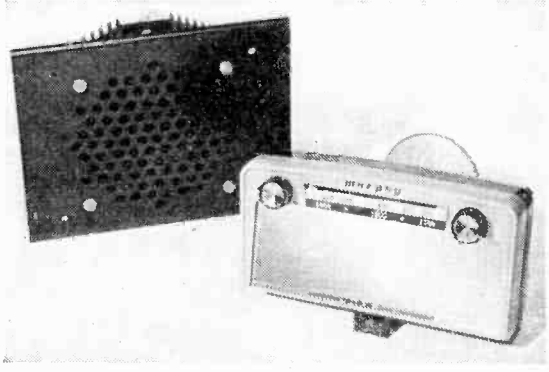
A most useful additional feature is now incorporated in the new Decca TM969 and TM-S2400 in the form of an interscan marker originating from "own ship" and variable in length and inclination, with direct reading of range and bearing from scales coupled to the controls. Any number of targets can be checked in rapid succession, and the use of a longer-persistence screen helps in showing change or—more important—lack of change of bearing with the minimum of effort.

In all, four new models have been added to the Decca range giving a choice of 12 types for varying requirements. One of these operates on 10cm (S-band) giving a high target/clutter ratio and better performance in the presence of precipitation. Two models have 16-in displays, and in all the new consoles particular attention has been given to the grouping of controls according to function and frequency of use. The display units hinge forward, giving instant access to circuits for ease of maintenance.

All the sets make use of narrow-beam slotted waveguide scanners with lower top weight and windage. The rotation rate has been increased to 20 r.p.m.

All-Transistor Car Radio

The new Murphy "Voxson" fully-transitorized, long- and medium-wave, twelve-volt car radio is made up of two separate units. One of these consists of a small cabinet *cum* rear-view car mirror (see illustration) which is attached via an adjustable ball and socket joint and suction cup to the car windscreen. This unit contains the volume, tuning and wave-change controls, the internal ferrite aerial, and the mixer, two i.f. and audio driver transistors. The 2½-watt audio output transistor, together with its associated heat sink, input and output transformers and 5-in loudspeaker form the other unit. This may be sited in any convenient position in the car, for example, under the dashboard. The total cost of both units is 20 guineas (including purchase tax).

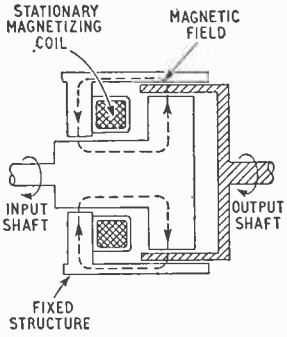


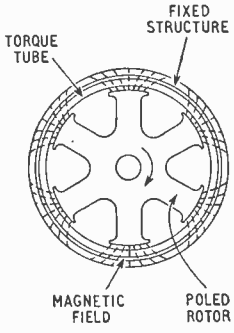
Technical Notebook

Transformer with a number of secondaries wound on separate parallel limbs is being developed by the G.P.O. With this arrangement, which is electrically equivalent to a number of ordinary two-winding transformers with their primaries connected in series, the parallel magnetomotive forces across each secondary are equal. The ampere turns are thus equal for each secondary so that the number of winding turns determines the secondary current rather than, as in a normal transformer, the secondary voltage. This new type of transformer is thus useful for feeding a number of current-operated devices such as transistors.

Peak Voltmeter in which the peak voltage storage capacitor is not, as is usual, charged directly from the input but rather from a flip-flop which is triggered from the input is described by R. P. MacKenzie in the June 17, 1960, issue of *Electronics*. In conventional peak voltmeters the indicated voltage may be too low at low input duty cycles because insufficient input current is available to charge up the storage capacitor to the full input voltage. In the circuit described by MacKenzie, as long as the voltage on the storage capacitor is less than the input voltage, their difference triggers a flip-flop which then for its unstable period charges the storage capacitor. Input voltage peaks thus continue to trigger the flip-flop to charge up the storage capacitor until the voltage on this capacitor reaches the input voltage and their difference is no longer capable of triggering the flip-flop.

Torque and Speed Control (TASC) units introduced by the Lowestoft Division of Pye Electric, Ltd., utilize inductive coupling to produce the control torque. The two cross-sectional diagrams show the construction of a typical unit. This consists of two independently rotating shafts and a stationary magnetizing control coil. The control input shaft is driven at a fixed speed and carries a poled rotor. This rotor is surrounded by an aluminium or copper torque tube attached to the control output shaft. (The larger units are driven in reverse, i.e. the input shaft carries the torque tube and the output shaft the rotor.) A fixed magnetizing coil concentric with the rotor is energized from a d.c. supply. This sets up a d.c. magnetic field (see diagrams) which streams out from the pole faces of the rotor and rotates with these poles. This induces currents in the torque tube and thus a magnetic field. The torque-tube and magnetizing-coil magnetic fields interact to produce a torque on the output shaft in the direction of rotation of the poled rotor. The magnitude of this torque is directly proportional to the value of the magnetizing coil current and is thus easily controllable. This torque is almost completely independent of the shaft speed. Three other advantages of this system of torque control are that no slip rings or brushes are used, that there is no physical contact between the input and output shafts except via the shaft bearings, and that the units may be stalled down without overheating. Applications of such units range over almost as wide a field as for electric motors.





"Change-of-State" Crystal Oven was described by D. J. Fewings (of Marconi's Wireless Telegraph Co., Ltd.) at the Brit.I.R.E. symposium on "Stable Frequency Generation" held last May. This type of oven utilizes the constancy of the melting point temperature of a substance to produce the required constant crystal temperature. Ideally such an oven would consist of the crystal imbedded at the centre of a sphere of a suitable solid substance which is in turn surrounded by a uniformly thick layer of the same substance in liquid form. The crystal and inner solid portion of the sphere will then eventually take up the melting-point temperature of the substance, and external temperature changes will then merely increase or decrease the amount of melted material, leaving the temperature nearly unchanged. The action of the oven depends on there being both solid and liquid layers of material present. The simplest practical way of ensuring this is to use a substance whose volume changes substantially on melting, together with an expansible closed container for the whole oven. The change in the volume of the container as the substance melts can then be used to operate the on/off switch for the oven heater, and this must uniformly heat the whole outer surface of the sphere. In practice the temperature control cannot be perfect because the necessary supports and connections to the crystal through the sphere provide paths along which heat can flow. However, a similar limitation applies to any type of temperature control. A suitable material to use is naphthalene, which has a melting point of 79.5°C and expands by rather more than 10% in volume on melting. In a practical case using such an oven an external temperature change of 14.5°C produced a crystal temperature change of only 0.084°C. For maximum crystal frequency stability it may be desirable to operate the crystal at the temperature at which its rate of change of frequency with temperature is zero. Crystals can be cut so that this temperature is within ±3°C of the melting point temperature of the substance used. Any remaining temperature difference could then be taken up by altering the melting point temperature by adding a suitable impurity to the substance. In the case of naphthalene anthracene is a suitable impurity: by adding up to 10% by weight of anthracene to naphthalene the melting point of the resultant mixture can be varied from 79.5°C to 76.4°C.

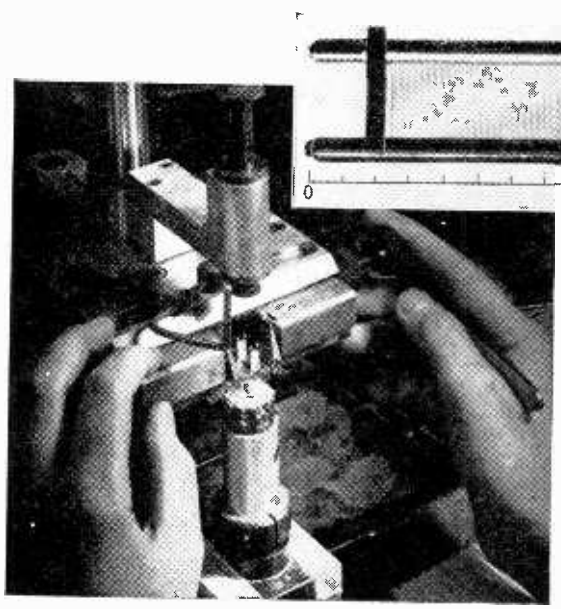
Low-frequency Noise can be obtained from high-frequency noise by sampling it at regular intervals and storing each sample until the next is obtained so as to produce a stepped noise output in which the step heights are equal to the sample amplitudes and in which steps occur whenever a sample is made. It can be shown that, if T is the time interval between successive samples, then 90% of the total power in the stepped noise output lies in the frequency range from 0 to 1/T. Although in this frequency range the

noise output decreases as the frequency increases from zero, the noise spectrum shape can be calculated and allowed for. A description of a low-frequency noise generator based on these principles is given by N. T. Slater in the August 1960 issue of *Electronic Engineering*.

Very-Low Frequency Propagation over long distances is being studied with the aid of a ship-borne 30MW (peak) pulse generator and 3,000-metre long helicopter-supported aerial according to an article by M. M. Newman *et al* in the July 22 issue of the American journal *Electronics*. With a transmission frequency of 20kc/s a signal strength of the order of 100μV/metre can be produced at a distance of 10,000km (6,200 miles) by means of this generator and aerial.

Optical Maser oscillator utilizing the fluorescence of synthetic ruby has been developed by the Bell Telephone Laboratories. The ruby is "pumped" with green light to produce "stimulated emission" at the frequency of the fluorescent colour (red). The ruby, which is the form of a rod 1½in long with a diameter of ⅛in, is held in the centre of a spiral photoflash lamp. The green component of the light from this lamp excites the chromium impurity atoms in the ruby. The excited chromium atoms at first rapidly relax from the excited quantum energy level to a metastable intermediate quantum energy level without emitting any radiation. The chromium atoms then rather more slowly relax from this metastable level to their original level, emitting red fluorescent light in the process. The fluorescent light first emitted stimulates the chromium atoms still in the metastable state to radiate at the fluorescent frequency, provided that the fluorescent light stays long enough in the ruby rod to provide sufficient stimulation. This proviso is satisfied by polishing the ends of the rod until they are exactly flat and parallel, and then partially silvering them. Some of the fluorescent light which is emitted within a small angle about the rod's axis is then reflected back and forth between the silvered rod ends for long enough to stimulate emission. It is this stimulated emission which distinguishes the action of this maser from ordinary spontaneous fluorescence. This stimulation process ensures both that the stimulated radiation is all emitted within a small angle about the rod's axis (an angle of about one-tenth of a degree was actually measured), and that the stimulated radiation is coherent (i.e. has the same phase at all points on either end of the rod). Coherence was proved by observing interference between the light from two fine parallel slits in the silver. Coherence has not hitherto been achievable with a light source. As with radio waves, it makes possible the communication processes of modulation, amplification and detection. Another property of the emitted light resulting from stimulation is that its bandwidth is only about one-sixtieth of that of normal fluorescent light, and it is hoped to achieve an even narrower bandwidth. This narrow-bandwidth property, as well as the fact that the light is all emitted within a very narrow angle, gives rise to a very bright source, in fact more than a million times brighter than the sun. This brightness should also be useful for communication purposes. The light from this maser has in fact been seen twenty-five miles away. With the present device, maser action can be sustained for about a millisecond at a time. During this time several hundred bursts of radiation spaced a few microseconds apart are produced, each lasting for about a microsecond. The stimulated emission is produced in pulses probably because, when stimulated emission occurs, it decreases the number of atoms in the metastable state so rapidly that the flash lamp is not bright enough to maintain a sufficient number of atoms in the metastable state to allow maser action to continue. Maser action then ceases, but commences again when the flash lamp has had time to produce a sufficient number of atoms in the metastable state. This alternate decrease and increase in the number of atoms in the metastable state then produces pulses of light.

Crystal-Frequency Variation with temperature can be compensated for (according to a letter from E. A. Gerber in the February, 1960 issue of *Proc. I.R.E.*) by applying a temperature-dependent force to the crystal so as to produce an opposite frequency change. A bimetal strip bearing on the crystal can be made to provide a suitable temperature-dependent force and, according to the direction of this force, a positive or negative compensating change in the crystal frequency can be produced.



Frame Grid Valve Manufacture

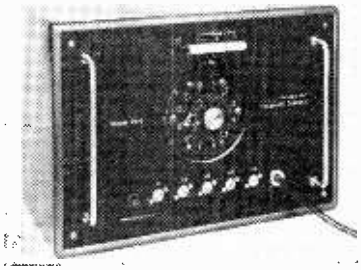
THE mechanical precision necessary for the handling of the fine wires (10 microns in diameter) and the assembly of frame grids with grid-cathode spacings of the order of 50 microns has called for the development of a completely new range of electrode winding and welding machines, and of assembly methods comparable with those in the watch-making industry. The accompanying photographs show a typical frame grid, and the assembly jig for the two grids of the PCC89 cascode r.f. amplifier, one of the four new high-slope television valves now in quantity production at the Mitcham Works of Mullard Ltd.

Manufacturers' Products

NEW ELECTRONIC EQUIPMENT AND ACCESSORIES

Precision V.H.F. Frequency Standard

A COMPACT and portable (but mains-operated) frequency standard for accurately checking the operating frequencies of mobile, as well as of fixed, v.h.f. radio transmitters has been introduced by Wayne Kerr Laboratories, Ltd., Chessington, Surrey. Known as Model FS100 it consists of a crystal-controlled oscillator, three



Wayne Kerr Model FS100 crystal-controlled frequency standard for testing mobile v.h.f. transmitters.

frequency multiplier units, wide-band detector and a.c. mains power unit for 110-130V or 190-240V, 40-60c/s.

The oscillator can be switched to operate with any one of 12 quartz crystals mounted in thermostatically controlled, plug-in ovens, two crystals being mounted in a single oven. Crystals for operation on fundamental frequencies within the range 7.5 to 9.7Mc/s can be used and each multiplier unit covers a specific part only of the total frequency coverage. For example, the Band I multiplier covers crystal frequencies of 7.5 to 8.17Mc/s giving final outputs on 3, 9 and 18 times as required of the frequency of the crystal selected. Between them the 3 multipliers will provide spot output frequencies of from 22.5 to 175Mc/s with an accuracy of 3 parts in 10^6.

Crystals are selected by a rotary switch mounted in the centre of the instrument panel, while multipliers are selected by means of push-buttons.

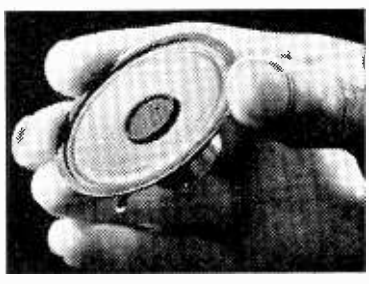
Signals from the transmitter to be tested are fed into the test set and the crystal and multiplier switches set to the transmitter's operating frequency and the output then checked for zero beat. The test set measures 13¼in wide, 9in high and 8¼in deep and weighs 16lb complete.

New Plessey 2¼in Loudspeaker

A NEW 2¼in diameter loudspeaker for use in modern miniature transistorized receivers has been introduced by The Plessey Company Ltd., Ilford, Essex.

The magnetic circuit uses a new constructional technique to enable the overall depth to be reduced to a minimum—a rod magnet being inserted into a split aluminium ring which is fitted into an accurately machined yoke. This design arrangement gives a compact, robust motor unit without the use of magnet assembly bolts.

The 2¼in diameter loudspeaker is available with a low impedance voice coil (8/10 ohms) for use with a matching transformer or alternatively with high impedance coils for direct connection into transistor circuits.



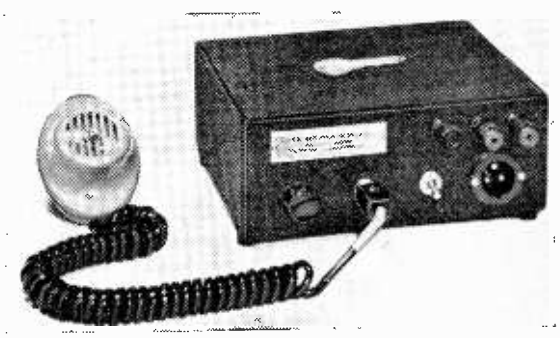
Plessey 2¼in loudspeaker has a depth of only 0.83in.

20W Transistor Amplifier

THE Type TR/2 transistor amplifier is a compact unit measuring 8in × 6in × 3in (high) and capable of delivering 20W peak a.f. output to 3.5-Ω or 15-Ω loudspeakers. It is intended primarily for portable and mobile PA applications and operates from a 12V d.c. supply, imposing a no-speech load of 0.25A and a mean working load of 1A.

It employs 5 transistors, one protective diode and a lightweight moving-coil microphone fitted with a press-to-talk switch, thereby ensuring maximum economy in l.t. consumption during intervals in operation. The price is £31 10s 0d including microphone.

Although a non-reversible l.t. input socket is fitted, a safety circuit to prevent damage to the transistors,



R.E.E. 20W transistor PA amplifier. The key gives a good indication of its size

should the battery polarity be reversed, can be included at a small extra charge.

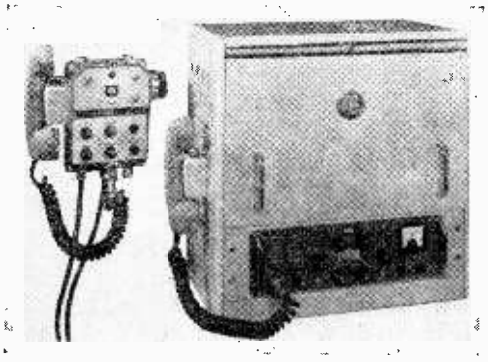
Further details can be obtained from R.E.E. Telecommunications Ltd., Telecomm Works, Market Square, Crewkerne, Somerset.

V.H.F. Marine Radio-telephone

SHOWN in the illustration is the latest Pye marine v.h.f. radio-telephone for shipborne use. It is suitable for use in large or small vessels having 100-150V or 190-240V, 40-60c/s a.c. supplies and operates on the frequencies allocated for inter-ship, ship-to-shore, harbour and docking telephone communications.

The equipment allows for operation on 28 channels in the international marine v.h.f. band, 9 channels being for single frequency simplex and 17 for duplex working. The 28 channels are provided by 18 crystals.

Frequency modulation is employed and the transmitter power output is 20W. The Type PTC8306 equipment complies with the Hague and British G.P.O.



Pye marine V.H.F./F.M. radio-telephone Type PTC8306. The remote control unit is on the left.

specifications for this type of equipment so it is suitable for international use as well as for use in home waters. Provision is made for full remote control over lines up to 200ft in length.

The makers are Pye Telecommunications Ltd., Newmarket Road, Cambridge, from whom further details can be obtained.

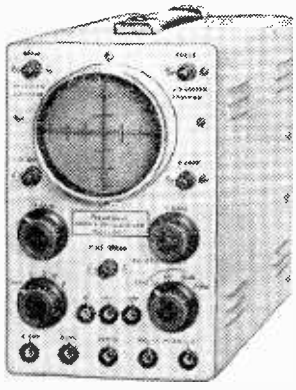
Oscilloscope Kit

THE Heathkit Model OS-1 enables an oscilloscope to be built with a Y-amplifier sensitivity of 14mV/cm and a response within ±3dB from 10c/s to 2.5Mc/s. The X-amplifier sensitivity is 1.4V/cm and its response within ±3dB from 15c/s to 500kc/s: the time-base range is from 15c/s to 150kc/s approximately. A 50c/s calibration source provides a peak-to-peak potential of 1, 10 or 50V to an accuracy of ±10%. A printed circuit board helps to ensure that all kits are wired exactly as required. The manual provided includes step-by-step wiring instructions, pictorial diagrams, and a circuit description and diagram. Operating voltages are also given. The Kit costs £18 19s 6d and is available from Daystrom Ltd., of Gloucester.

Transistor Oscillators

WITH the new Levell Electronics Types TG150 and TG150M battery oscillators sine waves can be produced at any frequency between 1.5c/s and 150kc/s and with any amplitude up to 2.5V into 600Ω. The harmonic distortion is <0.3% between 50c/s and 15kc/s and <1.5% below 50c/s and above 15kc/s. The frequency changes by <0.3% at 1kc/s for a 30% fall in the supply voltage and by <0.05% per °C temperature change. The output level varies by <0.1dB over the whole frequency range, by <0.05dB for a 30% fall in the supply voltage, and by about −0.02dB per °C temperature change. A thermistor stabilized Wien bridge circuit is used in these oscillators. The Type TG150M is fitted with a calibrated output meter and costs £36, a version of this oscillator without the output meter—the TG150—costs £27. These instruments are manufactured by Levell Electronics Ltd., of 10-12 St. Albans Road, Barnet, Herts.

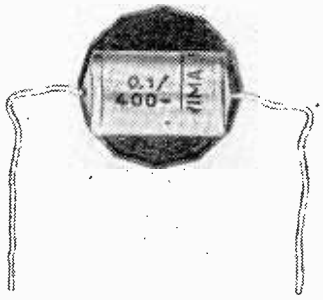
Right.—Levell Electronics Transistor Battery Oscillator. Type TG15M.



Left. Assembled Heathkit Model OS-1 oscilloscope

New Plastic Foil Capacitors

TROPYFOL capacitor is the name given to a new type of miniature capacitor which utilizes an aluminium-coated polyester foil dielectric rolled and impregnated in a plastic resin with axial end wires. They are available in 125V and in 400V types, the former with capacitance ranging from 0.01μF to 1μF and the latter from 0.001μF to 1μF. A 0.001μF capacitor in the 125V type measures 4.5mm in diameter and 12mm long and a 1μF size for 400V working is 13mm in diameter and 24mm long (0.5in × 0.9in approx.).



Tropyfol 0.1μF, 400V miniature capacitor.

Insulation resistance is said to be not less than 2,500 sec (MΩxμF) while in some cases it may reach 50,000 sec.

Supplies are available to the radio and electronics industries and further details can be obtained from Waycom Ltd., Empire Buildings, Duke Street Hill, London, S.E.1.

Very Low Temperature Coefficient Resistors

BY combining two wires of different temperature characteristics Alma Components have produced a range of precision wire-wound resistors with the remarkably low temperature coefficient of less than 4 parts per million per degree C. The wires are wound on non-hygroscopic ceramic formers encapsulated in a sealing resin. Three sizes are available rated at 1w (Type C), ½w (Type C2) and ¼w (Type C4) with resistance values of 100Ω to 300kΩ, 100Ω to 120kΩ and 100Ω to 80kΩ respectively. The winding is sectionalized with adjacent sections wound in opposite directions. Standard tolerances are 0.1%, 0.25%, 0.5% and 1%.

Further details can be obtained from Alma Components Ltd., 551, Holloway Road, London, N.19.

Principles of

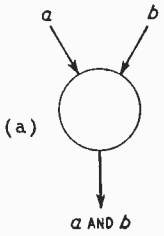
Digital Computers

By D. S. WILDE,
B.Sc., A.M.I.E.E., Grad. Inst. P.

2.—ARITHMETIC AND CONTROL CIRCUITS

IN the previous article methods of storing binary information in a digital computer were outlined. These digit patterns represent numbers and instructions and the function of the arithmetic unit (sometimes called the accumulator—Babbage called it the "mill") is to perform additions, subtractions etc. with these numbers, as dictated by the instructions.

A group of digits may be delivered from a store one after the other on a single channel (serially) or simultaneously with a separate channel for each digit (in parallel) and the choice must be made in the design of the computer between increased speed and economy of equipment. For example, a serial adder will take $nt + t$ periods to add two n-digit binary numbers occurring as pulse trains of period t (the final t is for the last carry). Parallel addition will only take $2t$ periods but there must be one adder per channel i.e. n adders.



a	b	a AND b
0	0	0
1	0	0
0	1	0
1	1	1

(b)

Fig. 3 (a) Symbolic AND gate. (b) Truth table for the AND gate.

It is possible to effect a compromise between both extremes and the Ferranti Mercury computer is an example of this. Access to the storage elements is parallel, the parallel digits are turned into serial form and dealt with by fast serial circuits.

Whilst the present tendency is for fully parallel machines, it is possible that with new types of storage operating extremely rapidly—perhaps up to 100 Mc/s—we may see a return to serial techniques and consequently smaller computers.

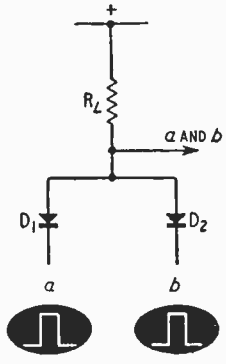
It has already been shown that the fundamental arithmetic operation is subtraction and that all the other common functions can be derived from it. Subtractions only occur about one-third as frequently as addition in most programmes, and since an addition operation performed in a subtracter would require two stages [$0-b$, $a-(0-b)$] a subtracter is an uneconomical component. An adder is always provided and a complementer then enables subtractions to be performed by complement addition.

Binary addition can be reduced to a set of logical (or Boolean) operations and these operations are performed by extremely simple electronic circuits. Given the necessary reduction details a binary adder can be easily synthesized, so can other functional units.

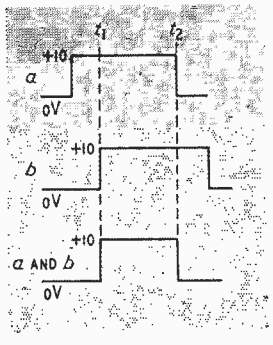
There are a variety of logical operations although only two are essential and the others can be derived from them. It is much more convenient however to use three basic logical functions, these are AND, OR, and NOT, and they are almost self explanatory.

The AND gate is shown symbolically in Fig. 3(a) and both input a AND input b must be present[9] to cause an output from the gate. There are four possible combinations for the conditions of a and b and these are shown in the "truth table" of Fig. 3(b) (1 signifies presence, 0 signifies absence). Only when $a = b = 1$ do a and $b = 1$ and hence the AND operation is equivalent to the algebraic product ab.

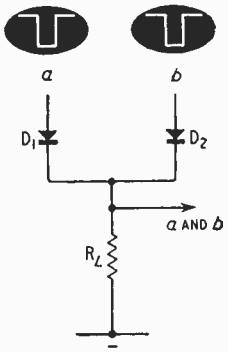
The circuit for such an AND gate is shown in Fig. 4(a) and in this case the inputs must be positive going and the supply rail is a positive rail. Suppose, in a practical case, that the supply is 100 volts and a and b



(a)

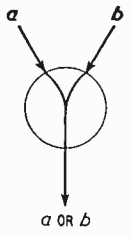


(b)



(c)

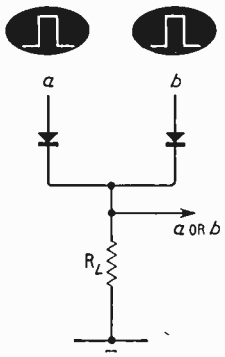
Fig. 4 (a) Circuit of an AND gate for positive-going inputs. (b) Input and output pulses for the AND gate for positive-going inputs of Fig. 4(a). (c) Circuit of an AND gate for negative-going inputs.



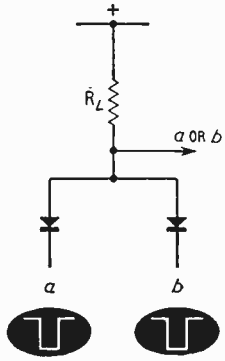
(a)

a	b	a OR b
0	0	0
1	0	1
0	1	1
1	1	1

(b)



(c)



(d)

Fig. 5 (a) Symbolic OR gate. (b) Truth table for the OR gate. (c) Circuit of an OR gate for positive-going inputs. (d) Circuit of an OR gate for negative-going inputs.

inputs are normally at earth potential. Both diodes will be conducting and if R_L is considerably higher than the forward resistance of the diode then the voltage drop across the diode will be negligible compared with that across the resistor. The output is therefore also at earth potential. If input *a* moves 10 volts positively then diode D_1 will become cut off. The diode D_2 remains conducting and hence its anode (and thus the anode of D_1) stays at earth potential. Thus although input *a* moves positively the output remains at earth. Only when *a* and *b* inputs move 10 volts positively together will the output rise by 10 volts. Fig. 4(b) makes this clear. For $t < t_1$ only input *a* moves positive and the output does not change. For $t_1 < t < t_2$ both *a* and *b* are positive and there is an output. After t_2 only *b* is now positive and there is no output.

A second type of AND gate is shown in Fig. 4(c) and this gate operates when inputs *a* and *b* are negative-going pulses, and the supply rail is negative. Only when both inputs move negatively together will the output move negatively.

Fig. 5(a) shows an OR gate symbolically. Its name suggests that input *a* OR input *b* being present will operate the gate and cause an output. The "truth table" is in Fig. 5(b) and the algebraic equivalent of *a* OR *b* is $a + b - ab$ and this can be checked by substitution of possible values from the "truth table". The OR operation is inclusive since both *a* and *b* being present together operate the gate.

The electronic OR gate for positive-going pulses is shown in Fig. 5(c) but in this case R_L is taken to a negative rail. Either input moving positive will cause the output to move positive. An OR gate circuit for negative-going pulses is shown in Fig.5 (d). An OR gate for positive-going pulses is identical to an AND gate for negative-going pulses; similarly an AND gate for positive pulses is the same as an OR gate for negative-going pulses.

NOT *a* is a very simple logical function and is algebraically equivalent to $1 - a$ since if $a = 1$, NOT $a = 0$ and if $a = 0$, NOT $a = 1$.

Electronically this corresponds to a voltage inversion and a simple valve circuit is shown in Fig. 6.

If *a* is a negative-going pulse from earth potential then the pentode will be bottomed when its grid is at earth and will be cut-off when the grid goes negative. The anode potential will be low when the valve is bottomed and high when cut off. The anode excursions are applied to the potentiometer chain R_1 and R_2 which can be chosen in conjunction with V_2 to ensure that as the input *a* moves from earth negatively the output NOT *a* moves from a negative potential to earth. D_1 merely serves to prevent the output going above earth potential.

In early computers the diodes in AND or OR gates were thermionic and valves were used for inversion circuits. The diodes are now semi-conductor types and the inversion circuits are transistors.

Using only these three circuits, AND, OR and NOT, it is possible to construct a binary adder. There is an additional circuit required for a serial adder however, this is a delay.

First it is necessary to establish the "truth table"

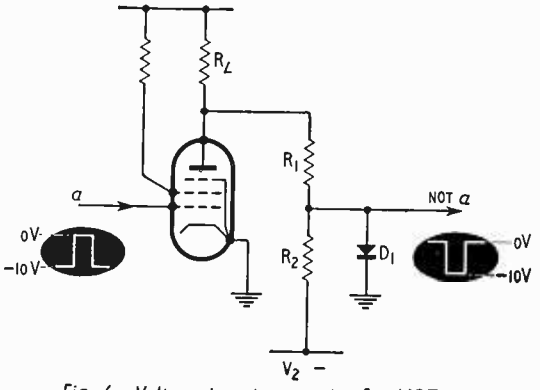


Fig. 6 Voltage inverter circuit of a NOT gate.

a	0	0	0	0	1	1	1	1
b	0	0	1	1	0	0	1	1
c	0	1	0	1	0	1	0	1
ANSWER	0	1	1	0	1	0	0	1
CARRY	0	0	0	1	0	1	1	1
a OR b OR c	0	1	1	1	1	1	1	1

Fig. 7 Truth table for binary addition.

for binary addition (Fig. 7). There will be three digits to add; these will be from the addend, the augend and the carry digit resulting from the addition of the previous digits. With three inputs, each of which can be either 1 or 0, there are eight possible combinations of inputs to the adder. These are shown in the "truth table" together with the answer (1 or 0) and carry (1 or 0) which must result.

Suppose that the three inputs are applied to an OR gate. Whenever there is a 1 among the inputs there must be a 1 in the output. If all eight combinations are tried the output agrees with the required answer except when two of the inputs are 1's together. (The output will be 1, the correct answer should be 0.) There must be an additional set of circuits to inhibit the output of the OR gates under these conditions. In other words the required answer is (a OR b OR c) AND NOT [(a AND b) OR (b AND c) OR (a AND c)]. The logical diagram now looks like Fig. 8.

The circuit combination responsible for inhibiting the output when only two 1's occur can also be used to generate the carry pulse since there must be a carry developed when two (or three) ones are present. Unfortunately the inhibit gates will inhibit the output when three 1's are present at the input and no answer digit will appear though one is required. A three-input AND gate is included therefore and its output is applied to a two-input OR gate whose second input is the previous output.

This logical configuration now satisfies all eight conditions of input giving the correct answer digit and the correct carry (Fig. 9). The carry digit is applied to a delay of one digit period and is fed back to the input, arriving in the next most significant place.

The same logical considerations apply to adders for a computer working in the parallel mode. The carry digits in this case are not delayed to a more significant time period but are applied as third inputs to a more significant adder.

There are other forms of binary adders and a binary subtracter can be developed in a similar way. The final step in the design is the substitution of circuit elements for logical symbols, and these have already been shown.

Whatever alternative solutions are found to the design of a specific logical circuit, Boolean algebra can provide a simple check that the circuit performs the function required. In the example chosen of the adder circuit the logical function is written as

$$\text{Answer} = (a \text{ OR } b \text{ OR } c) \text{ AND NOT } [(a \text{ AND } b) \text{ OR } (a \text{ AND } c) \text{ OR } (b \text{ AND } c)] \text{ OR } (a \text{ AND } b \text{ AND } c)$$

$$\text{Carry} = (a \text{ AND } b) \text{ OR } (b \text{ AND } c) \text{ OR } (a \text{ AND } c)$$

Previously it has been shown that a AND $b = ab$, a OR $b = a + b - ab$ and NOT $a = 1 - a$. Algebraic substitutions can thus be made. Working the final expressions is rather tedious but a glorious simplification is available because $a^n = a$ (since $a = 1$ or $a = 0$). If the above substitutions are made then

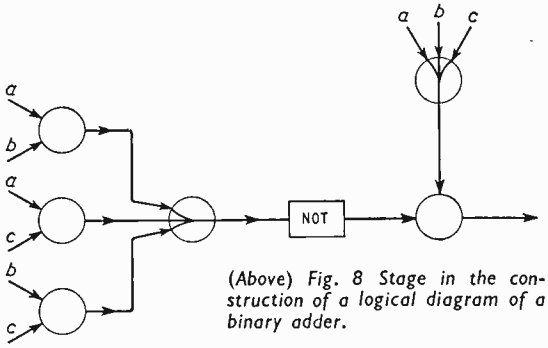
$$\text{Answer} = (a + b + c) - 2(ab + ac + bc) + 4abc$$

$$\text{Carry} = ab + ac + bc - 2abc$$

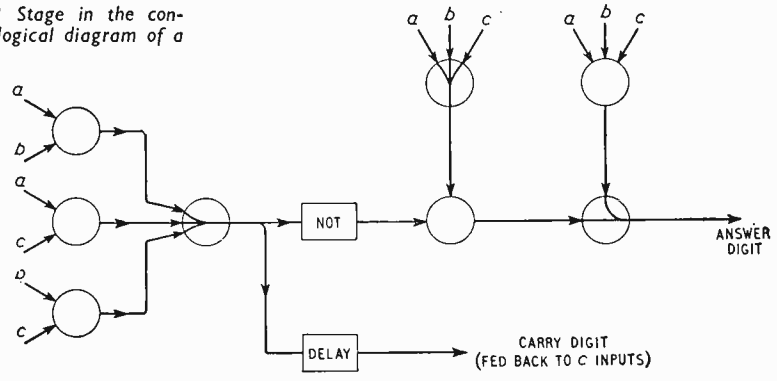
and any binary adder must satisfy these conditions.

Control Unit.—The control part of the computer is responsible for reading and sequentially obeying instructions which are held in the stores. Generally an instruction is divided into two parts, a function section (add, subtract, multiply, input, output, etc.) and address section (locating in the store the number that the function is to be performed on).

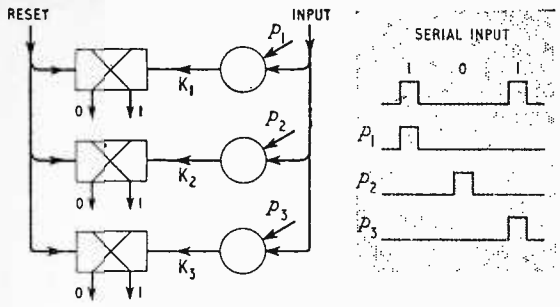
In the case of a serial computer the instruction will emerge from the storage as a series of pulses. The pulse pattern is a code and must be decoded to operate various gates in the computer which allow numbers to be routed to the various parts of the computer (the arithmetic units, the output units, another store location, etc.). Since only one pulse occurs at a time a pulse pattern can only be decoded if the individual pulses are staticised (" remembered ") and all compared together after the last one has occurred. The staticisor most commonly used is the well-known bi-stable element (other names used are Kipp Relay, flip-flop, multivibrator, Eccles-Jordan circuit, and toggle). The circuit consists of a pair of valves (or transistors) cross connected from anode to grid (or collector to base). A pulse input applied to one grid causes one of the valves to conduct, the second to cut



(Above) Fig. 8 Stage in the construction of a logical diagram of a binary adder.



(Right) Fig. 9 Logical diagram of a binary adder giving both answer and carry digits.



(a) (b)

Fig. 10 (a) Staticisor (store) for serial input train of three binary pulses. (b) Serial input train and clock pulses for storing 101 in the staticisor of Fig. 10 (a).

off and this state is maintained until a trigger pulse is applied to the other grid when the circuit changes state.

A set of three bistable elements is shown symbolically in Fig. 10 and the serial pulse train is applied to them via two-input AND gates. The second inputs to the gates are single clock pulses; they behave in the manner of a strobe pulse and p_1 is coincident in time with the first pulse of the pulse train, p_2 with the second, and p_3 with the third[10]. In the case of a pulse train of 101 the first bi-stable element will receive a trigger since p_1 and the first 1 of the pulse train coincide and there will be an output from the AND gate. p_2 coincides with a 0 (no pulse) and there is no output from the gate, hence the second bi-stable element is not triggered. The third one is triggered, p_3 coinciding with the third place. The pulse pattern 101 has now been stored (or staticised) and the bi-stable elements are said to be in the 1, 0, and 1 state respectively.

With three bi-stable elements there are eight possible combinations in which they can be set. These are, of course, determined by the input pulse train and could represent eight possible functions.

It is necessary to decode these eight possible states to uniquely define each of them. Fortunately this is an easy matter for a decoder is merely an AND gate; eight three-input AND gates are necessary to decode three binary digits. These are shown in Fig. 11. The first digit has its inputs connected to the 0 side of the bi-stable elements. For this type of AND gate, positive inputs are required and the 0 side of a bi-stable element is defined as that side being at a positive potential when no input trigger has been received. The 1 output must therefore be at a negative potential under these conditions. Thus if the 0 side of the three bi-stable elements are connected to the first decoding AND gate and no input triggers have been received the output of the decoder will be positive. For the second gate the 0 sides of two of the bi-stables are inputs and the 1 side of the third bi-stable is the third input. If the pulse pattern 001 is now staticised the second decoder has an output, since both 0 inputs are positive (the bi-stables have not been triggered) and the 1 input is positive (the third bi-stable has been triggered and now the 1 output is positive, the 0 output negative). This method of decoding can be extended to the remaining six combinations of digits and whatever the input pulse train may be one, and only one, of the eight decoders will register an output.

Simple Computer.—With storage, an arithmetic unit, and a control unit we have enough components to construct a simple digital computer. In addition to its logical circuits there must be a timing cycle generated to ensure sequential operation.

Associated with the store are its address decoders. These behave exactly in the manner of function decoders but select the location of a number or instruction in the store, and in this example the store may be of the electrostatic or magnetic core type, not the delay-line type.

The control unit has a two-line store and an adder in its read/write loop. Associated with it are function and address staticisors.

The arithmetic unit consists of a store acting in conjunction with adders and subtracters.

There are six instructions in the simple programme to be performed and the computer can perform four functions. These are defined by 00 (ADD), 01 (SUBTRACT), 10 (RETURN TO STORE), and 11 (STOP). The store has eight lines in it and the eight addresses require three digits to specify them.

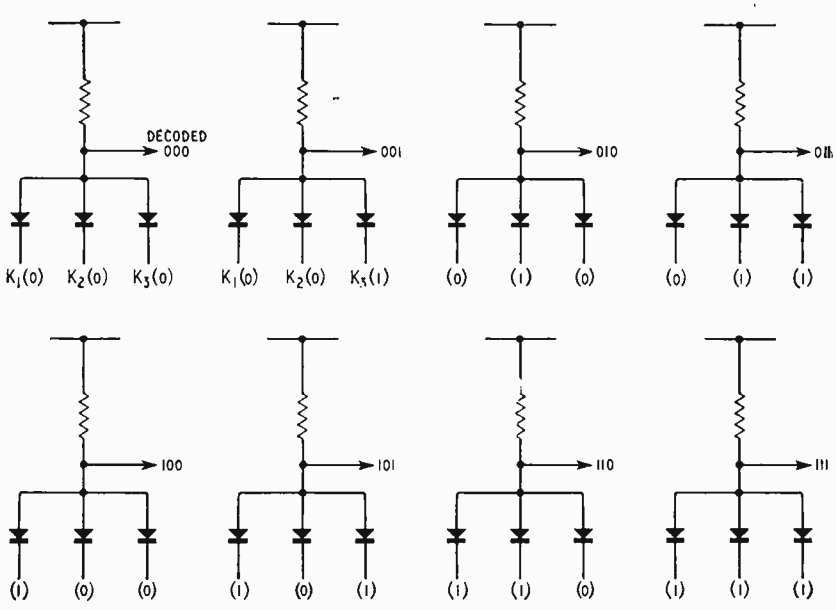


Fig. 11 Set of eight AND gate decoders for the eight possible states of three bi-stable elements.

Instructions are therefore five digits long.

The cycle of operations can be defined by four time periods T_1, T_2, T_3, T_4 and one instruction is selected and obeyed during each cycle of four periods. What happens in each time period is detailed below.

T_1: add unity to the top line of the control store. This control address initially has zero stored in it and its job is to read instructions from the main store one by one. During T_1 the top line is read from the control store into the control adder through the STOP gate, which is open unless a STOP instruction is being obeyed. The number which emerges from the adder is used to set up the address and function staticisors and it also replaces the old number in the control store top line.

T_2: in this period the contents of the store address specified by the control unit in T_1 will be read out and transferred to the second line in the control store. This is the instruction which is to be obeyed.

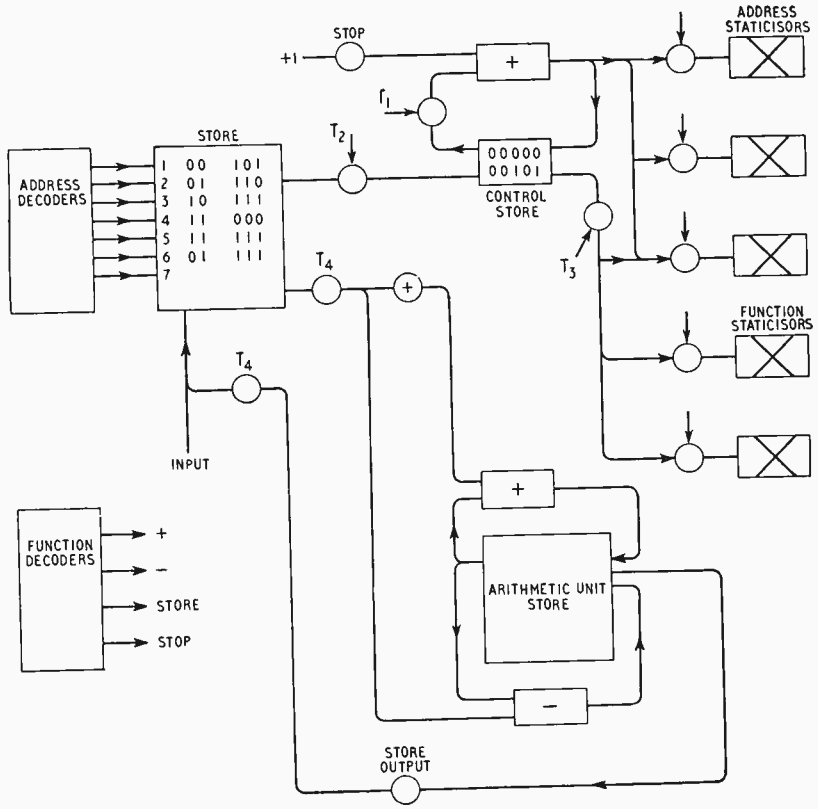


Fig. 12 Simple computer.

T_3: the instruction in the second line of control is now read out to the function and address staticisors which are set up.

T_4: the number specified by the setting of the address staticisors is read out of the main store and is operated on in the manner determined by the function staticisors.

To show how this sequence of operations works in practice the simple programme shown in Fig. 12 will be followed through. The computer, which has four functions and an 8-address store, initially starts with the programme in the main store and the control store and arithmetic unit store empty. In the first T_1 period 00000 is read from the control store, 1 is added to it, and the address staticisors are set to 001. The first two (function) digits (00) are not set up since the function staticisors are only set in period T_3. During T_2 line 001 is read from the store; its contents (00,101) pass through the gate marked T_2 into the control store. This is the first instruction and the code 00,101 is interpreted by the computer as "take the number stored in line 5 (101) and add it (00) to the arithmetic store contents".

This instruction is staticised on the function and address staticisors in T_3 and the function staticisor decoders open the gate marked + and the address staticisor decoders select line 5.

The contents of line 5 (the number 11111)* is routed to the arithmetic unit adder and arrives simultaneously with the read-out contents of the store. Addition is performed and the answer is stored. The first instruction has now been completed and the cycle repeats for the second instruction (01, 110). This can be interpreted as "subtract from the arithmetic unit total (01) the number stored on line 6 (110)". In T_4 of the second cycle the number on line 6 (01111) is fed to one input of the subtracter through the gate marked —. The number in the arithmetic store (11111) is read into the subtracter at the same time and the answer (10000) is returned to the arithmetic store.

The third instruction (10111) reads "transfer the number in the arithmetic store (10) to line 7 (111) of the store".

The fourth instruction merely says STOP. The decoded stop instruction closes the stop gate and no further adding of unity takes place in the top control line. Hence no subsequent instructions can be read and the programme has been finished with the final answer (10000) now in the main store in line 7.

This programme is an extremely simple one but it does show the way in which the basic elements work in conjunction with one another in doing a simple calculation. It illustrates also an important point from von Neumann's researches. This is that numbers and instructions were of exactly the same form. They both had five binary digits and were differentiated by the layout in the store which would be decided by the programmer. There is considerable flexibility to be gained since some programmes use few instructions but have a very large amount of numbers stored, whilst others use few numbers but a considerable number of instructions. The computer is therefore much more compact than if sepa-

* This is not intended to be a negative number in this example.

rate stores were provided for numbers and instructions.

An additional and extremely important consequence is that instructions can be modified in the course of the programme by using them as if they were numbers and processing them in the arithmetic units to give new instructions.

The simple programme did not exploit the "decision facility" which was recognized by Babbage as essential to an automatic computer. A short series of instructions will illustrate the importance of this "decision facility". Suppose it is required to divide 9 by 3. This can be done by simple subtraction, counting the number of subtractions performed before the answer goes negative, and this is the required quotient. The programme would read

(1) Subtract 3 from the number in the arithmetic store (9).

(2) Test the answer to see if it is positive. If it is, proceed to instruction (3), if it is not, STOP. (For this purpose 0 is a positive number.)

(3) Count 1 and store it.

(4) Repeat from instruction (1).

The test facility is not difficult to achieve in practice since it has been shown that negative binary numbers are recognized by having a 1 in the most significant place. Detection of this 1 is the deciding factor in whether the computer carries on its programme or whether it stops. Far more sophisticated uses are made of this property but they cannot be dealt with here.

The principles of digital computers are simple, but a full scale computer is obviously a much larger collection of elements than those discussed in this article. There are many additional circuits necessary which are concentrated on connecting the computer to the outside world, but the aim of these articles has been to emphasise the basic simplicity at the heart of even the most mighty machines.

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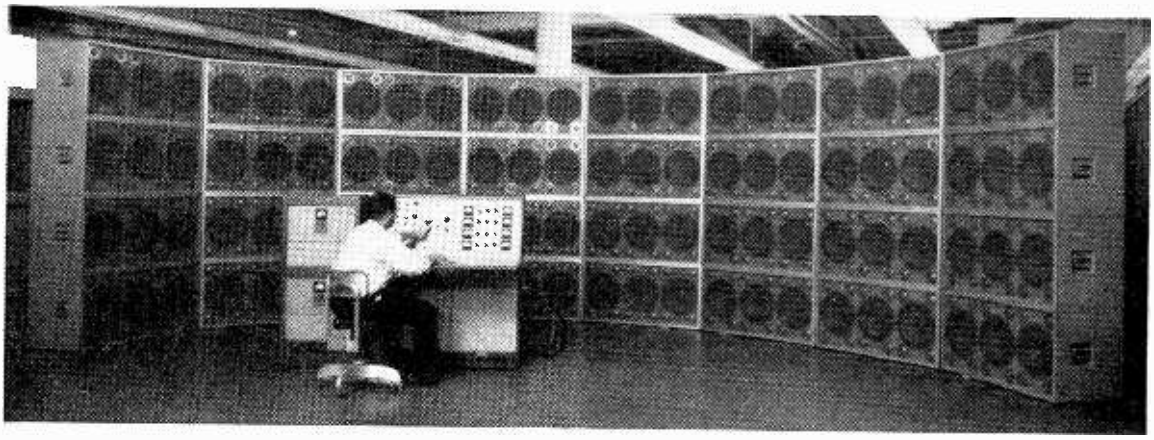
[9] "Electronic Computers" (2nd edition.) T. E. Ivall, Iliffe, 1960, p. 100.

[10] *Ibid.* p. 120.



High-power Loudspeaker System

By MICHAEL LORANT

FOR STUDYING THE PHYSIOLOGICAL EFFECTS OF HIGH-INTENSITY SOUND

RESEARCH technicians of the Acoustical Engineering section of Stromberg-Carlson have recently developed for the Aerospace Medical Division of the Wright Air Development Centre, Ohio, a new high-intensity acoustic system for studies of the physiological effects of high-intensity sound.

The most unusual feature of the new system is the "high-fidelity" quality of its performance—the generation of undistorted sound throughout the full 10-octave range of normal audibility.

The "business end" of this system is a huge assembly of loudspeakers—480 in all. These are mounted in 32 separate baffles for maximum flexibility in arrangement and control. Each baffle contains three low-frequency "woofers" and twelve high-frequency "tweeters". All the loudspeakers are especially designed to deliver "high-fidelity" sound at high acoustic powers for sustained periods.

The system is controlled from a console providing four possible inputs—sine wave, electronic "white noise", tape recordings (of jet engine, missile, etc.), or an external source.

The main audio power equipment consists of two pairs of audio amplifiers. One pair of these is for "low-power" use only, with each amplifier providing an output of 200 watts. Each of the pair of high-power amplifiers has an output of 7,000 watts. The frequency response of the system is "flat" over the entire audible range, from 20 to 20,000 c/s.

To avoid unintentional exposure of subjects to high-intensity sound, a safety precaution makes it necessary for the operator to put the controls first into the low-power position before energy can be supplied to the high-power amplifiers.

VALVE NOISE

By "CATHODE RAY"

A MAIN ambition of power engineers is to generate electricity direct from heat, instead of going through the tiresome sequence of using the heat to boil water and making the steam impinge against blades in a turbine, causing it to move an array of conductors in a strong magnetic field. They may or may not be encouraged by the fact that direct conversion of heat into electrical energy does take place in absolutely every circuit. The evidence is before our very eyes—and ears—in every TV screen and loudspeaker receiving weak transmissions. The annoying thing is that this electricity is random, and therefore not only useless but detrimental.

Last month we considered the constant factor connecting temperature with random electrical power ("noise"): Boltzmann's constant, denoted by k. Since this form of electrical power is worse than useless, the fact that we get a very poor rate of exchange is a point in favour rather than otherwise. In our ordinary units, k is only 1.38×10^{-23} joule per °K. The resulting noise voltage across a resistor or tuned circuit is of the order of one or two microvolts. But of course that is enough to be a serious nuisance if the signal we are trying to receive is of the same order. When amplified 120dB, microvolts become volts. The most significant source of this universal circuit noise (called thermal or Johnson noise) is obviously the circuit followed by the greatest amplification. In fact, if the first stage of amplification is doing well, the contributions from circuits other than its input circuit may be neglected. But Johnson noise is not the only kind that causes the escaping-steam sound in the loudspeaker and the animated graininess on the screen.

If the subject of valves is not too *passé*, *démodé*, *suranné*, *vieux jeu*, *radio à la vapeur*, or any of the other contemptuous French epithets we may choose to bestow on it in these transistorizing days, let us consider how they too contribute their quota of noise. Even the transistor hounds may find it worth their valuable time to do so, for at bottom the principles of transistor noise are similar.

One thing had probably better be made clear at the start: so far as the end product is concerned, valve noise is the same as Johnson noise. There is nothing to give a clue as to how much is due to valves and how much to circuits. (To cover myself against argumentative readers I had better declare a possible exception: two ingredients of valve noise to be mentioned might be recognizable by their tendency to occur increasingly at one end or other of the frequency scale.)

As has just been hinted, valve noise can be subdivided. The basic ingredient is what is usually called shot noise or shot effect. Sometimes writers (for the sake of effect?) name it in German, as Schroteffekt, which sounds even more penetrating. The air of mystery and confusion is further heightened by others who call it (wrongly, as it happens) Schottky effect, because it was first described by one Schottky. All these names are even more than usually subject to individual variations in spelling.

The thing was called shot noise (to come back to plain English), so we are told, because of its supposed resemblance to the sound of shot peppering a target. Since the sound in question, even after enormous amplification, is much more like a gentle hiss of steam, I prefer to think that the reference to shot is more to remind us (or even inform us, if we are beginners) that the flow of electric current through a valve is not perfectly smooth like the flow of treacle from spoon to plate, but more like the flow of water from cloud to earth, as rain.

The merit of likening it to shot or even rain is, I think, confined to the simple idea of current being made up of discrete particles and therefore subject to random variations from an average rate of flow. In other ways it is misleading. A fairly obvious discrepancy is that what we get is not the magnified sound of electrons striking the anode, but a result due to random fluctuations of current in the anode circuit. A less obvious but most important difference is that shot has no effect on the target before actual impact. To be quite correct I suppose we must say that the first effect is produced by the extra pressure of air pushed against the target by the shot, but by that time the shot is virtually home. With electrons in a valve it is quite different. Electrically, they affect the anode circuit all the time they are travelling there from the cathode, and arrival marks the end of this influence, not the beginning. The fact that the movement of an electric charge near a conductor induces a current in the conductor used to be demonstrated by one of the stock gold-leaf-electroscope experiments of the nineteenth century. Nowadays I suppose one relies on Conservation of Energy. Q in Fig. 1 is the negative charge on a particle moving in response to the constant electric field between a pair of electrodes having a difference of potential V. (The field strength is V divided by the distance between the electrodes.) As its potential is being raised, work is being done on it, and the requisite energy can come only from the battery, through which a corresponding charge must therefore pass. The faster Q moves, the greater the rate of charge flow through the circuit; i.e., the greater the current. Assuming an electron starts from rest at the cathode, and the field is uniform, its acceleration is constant, so its velocity steadily increases, and the current waveform is as in Fig. 2.

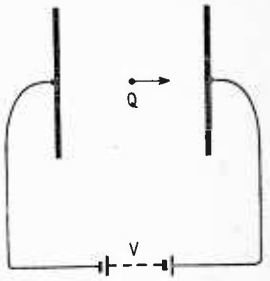


Fig. 1. A negative charge Q is moving towards the positive plate under the influence of the electric field between the plates. The work thus done on it by the battery necessitates a current through the battery.

For the sake of a nice round number, let us suppose

the anode current in a valve is 16mA. The rate at which electrons cross the vacuum must then be 10^{17} per second. If they were released at exactly equal intervals the anode current would therefore be modulated at a fundamental frequency of 10^{17} c/s. That is in the X-ray band, so we are safe in assuming that it would be smoothed out into imperceptibility in any practical anode circuit. But although the average rate of flight is 10^{17} per second, owing to the nature of thermionic emission this rate fluctuates in a random manner around its average, rather like the day-to-day fluctuation in actual births compared with a steady long-term average. At the foot of Fig. 3 the ideal waveform of Fig. 2 is repeated at intervals representing an average of eight electrons in flight at any one instant, but varying irregularly. Above is the result of adding all these pulses, and we see that it is mostly d.c., with a very high-frequency ripple—the one we are assuming is smoothed out, like the residual r.f. in a detector circuit—and a comparatively slow and quite irregular variation of the d.c. from its average. This last is the shot noise current.

It should be clear by now that the name " shot noise " is misleading in another respect: any idea that we are hearing even an indirect effect of the separate electrons pattering on the anode is completely unfounded; their frequency is far too high.

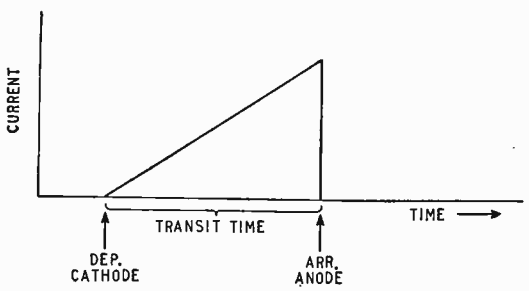


Fig. 2. Assuming a uniform field in Fig. 1, the charge is accelerated uniformly, and since the current in the circuit is proportional to the charge's velocity it increases steadily throughout the flight.

Just to make sure, and for the fun of the thing, I calculated what sort of a current Fig. 3 really represented, assuming the fairly typical transit time of 10^{-9} sec. The average rate of arrival of electrons is than 8×10^9 per sec., and as the frequency of the sawtooth ripple is the same—8×10^9 c/s or 8 Gc/s—it is actually a microwave frequency, with a wavelength of $3\frac{3}{4}$ cm. We may perhaps be surprised to find the electron frequency inside a commercially used radio waveband. But lest we imagine a great peak of noise at this particular frequency, let us remember two things. The first is that in this case one cycle is only one-eighth of the transit time, so is right outside the working frequency of the kind of valves we are considering. The second is that the anode current is only 0.001μA, which wouldn't do much anyway. But it is easily measurable, even though as few as eight electrons at a time are in transit between cathode and anode; which makes one think.

In practical valves the anode current is millions of times larger, and the sawtooth ripple (which is " shot noise " in the most literal sense) is correspondingly higher in frequency and can be left right out of account. But the slower ups and downs, due entirely to the fact that electrons are not emitted at regular intervals, are only too evident in high-gain amplifiers. Their power is distributed evenly over the frequency band. While this fact may seem natural for a purely random effect, so that we might have guessed it, it does need to be proved. Anyone sufficiently interested can wade through (e.g.) 15 pages of difficult mathematics in Davenport and Roots " Random Signals and Noise." Don't ask me to put it into a few lines of elementary algebra. I have to be content that the authorities agree on

$$I_N^2 = 2eI_aB$$

where I_N is the r.m.s. shot noise current, I_a the anode current, e the electric charge of one electron (1.6×10^{-19} coulomb), and B the frequency bandwidth. We may note in passing that I_N is proportional to the square root of I_a, so it doesn't do to starve the first valve in a high-gain amplifier. When the anode current is on the small side the gain is almost directly proportional to I_a, so signal/noise ratio would get worse if I_a were reduced too much.

Actually it is rather too soon to start drawing such conclusions, for the formula just quoted is limited to such exceptional cases that we are unlikely to find any use for it. One of the rare exceptions is a bright-emitter diode run with such low filament voltage and such high anode voltage that every electron emitted is immediately pulled across the vacuum. In other words, the anode current depends entirely on cathode temperature, not anode voltage. Its technical description is a temperature-limited diode. Another exception is a photoemissive cell.

Valves as normally used are run at a cathode temperature that emits more electrons than are required. Imagine a great crowd of delegates to a conference moving out after the first session into a room with a buffet at the far end. The first arrivals spot it and stream across, but the main body can't even see it for the crush, and mill around just inside the entrance. They form a " space charge " screening the attractions of the buffet from the late entrants. This is roughly what happens in a valve (Fig. 4). Suppose the emission is at the rate of 1 amp. That is 6.4 billion (American trillion) electrons per microsecond. Even before the cathode is fully hot after switching on, enough electrons have emerged to build up a negative charge near the cathode that more than counterbalances the positive attraction of the comparatively distant anode. So nearly all the electrons emitted from then on are repelled back to the cathode. Only the few within sight, as it were, of the anode feel its attraction and stream across, forming a current of perhaps a few milliamps. If none at all left the cathode permanently, the space charge would soon be used up, but of course the slightest reduction in its numbers reduces its repelling power and allows some of the emitted electrons to join. And so a balance is reached between the attraction of the anode and the repulsion of the space charge, resulting in a certain rate of anode current, depending on the anode voltage.

A space-charge-limited diode (for that is what we are talking about) is therefore like a triode in which the part of the negative grid, controlling the flow of electrons to the anode, is played by the space charge. It is really like automatic grid bias, as produced by a cathode resistor. Any increase in cathode current

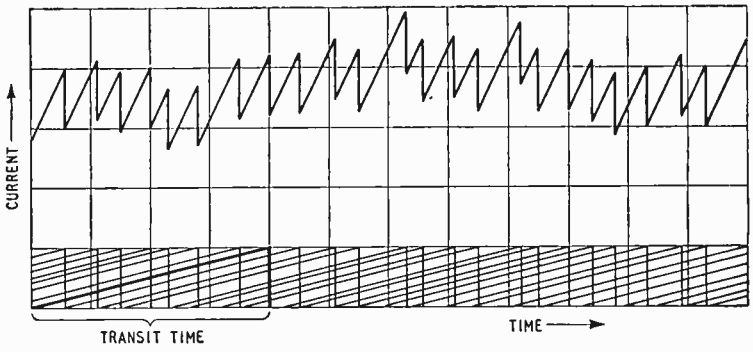


Fig. 3. Here there are, on the average, 8 electrons in flight all the time, but they start at irregular intervals. The resulting total current therefore has a slow irregular fluctuation as well as the fast saw-tooth ripple.

increases such bias and checks the increase in current. Similarly an increase in emission, due perhaps to mains voltage rising, increases the space charge and repels more electrons back to the cathode, so the current remains fairly constant.

The purpose of the negative grid in a triode is to supplement the space charge, reducing the anode current as required, even down to cutting it off altogether. So long as the potential of the grid is not allowed to rise high enough to attract electrons to itself, a triode behaves similarly to a diode as regards noise.

And how is that? Well, suppose the delegates were released from the conference room at short irregular intervals at such a rate that no crowd could form; the rate of flow across to the buffet would be equally irregular, as in a temperature-limited valve. A crowd, on the other hand, would tend to even out such irregularities and ensure a relatively steady flow. This is much more certain with electrons, which, being free from individualities such as varying degrees of hunger, politeness or sociability, work according to simple and predictable laws. That is not to say that the quantitative working out is not even more difficult than in the temperature-limited case. But having just seen that the space charge works rather like automatic grid bias, counteracting changes in anode current, we should not find it hard to understand that it has a cushioning effect on irregular emission, as indeed experience confirms.

In our ignorance of the extent of this noise-reducing or smoothing effect it can be brought into the formula for the temperature-limited valve as a factor, say S:

$$I_N^2 = 2\,SeI_aB$$

It is found that S can be as small as 1/50, signifying a 50-fold reduction in noise, but something like 1/5 is more usual. Note that this is in a formula for I_N squared, which is proportional to noise power; don't confuse it with an equivalent factor ($=\sqrt{S}$) that is sometimes used in the formula for I_N.

The question of noise in diodes seldom arises—except when they are used as frequency changers in microwave receivers—so we pass on to amplifying valves, especially those that might be considered for first-stage positions. One of the things designers want to do is compare valve noise with circuit noise. As we have seen, the only circuit that matters very much, usually, is the grid circuit of the first stage. The amount of effort worth expending on reducing this depends on how much noise the valve contributes. If circuit noise is given in microvolts at the grid, and valve noise in microamps in the anode circuit, one has to do calculations to find out which is greater, and by how much. It is of course possible to find how many microvolts at the grid would cause that number of microamps of noise, but direct comparison with circuit noise microamps would be vitiated by the fact that both figures depend on the respective frequency bandwidths, and it would be a coincidence if they were equal.

So the convenient custom is to express valve noise in terms of the resistance which, if included in the grid circuit of a noiseless but otherwise similar valve, would cause the same amount of noise. Let us call this imaginary resistance R_N. According to the formula we already have for the noise voltage at the terminals of a resistor,

$$V_N^2 = 4kTBR_N$$

I_N is related to V_N by the mutual conductance, g_m:

$$I_N = g_m V_N$$

So substituting $2SeI_aB/g_m^2$ for V_N^2 in the previous equation we get

$$\frac{2SeI_aB}{g_m^2} = 4kTBR_N$$

$$\therefore R_N = \frac{SeI_a}{2g_m^2kT}$$

This doesn't get us where we want, unless we know S. The rather difficult working-out I mentioned gives

$$S = \frac{1.28\,k\,T_c\,g_m}{e\,I_a}$$

where T_c is the temperature of the cathode. Substituting this in the equation for R_N we get

$$R_N = \frac{0.64\,T_c}{g_m\,T}$$

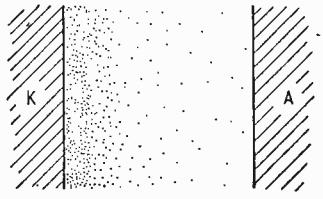


Fig. 4. The many electrons emerging from the cathode, on the left, form a negative space charge that neutralizes the distant positive charge on the anode and restricts further movement towards it. The surplus electrons are forced back to the cathode.

The cathode temperature T_c is usually about 1130°K and the room temperature T about 290°K, so

$$R_N = \frac{2.5}{g_m}$$

Because of the various assumptions in the smoothing theory, as well as the temperatures, this conveniently simple formula is far from precise, but it does at least give a rough idea. A moderate g_m for a triode is 2.5 mA, which makes $R_N = 1k\Omega$.

At frequencies less than say 30 Mc/s, noise resistance of this order is hardly worth bothering about as a noise source, compared with the usual grid-circuit resistance, to say nothing of man-made noise and atmospherics, both of which are worse at the lower frequencies. At very high frequencies, however, all these other noises are so much reduced that shot noise is appreciable and choice of first valve is correspondingly important. And at these same frequencies another effect adds to random noise. It concerns the electrons streaming through the grid.

We are still assuming that the grid is kept sufficiently negative to prevent any electrons landing on

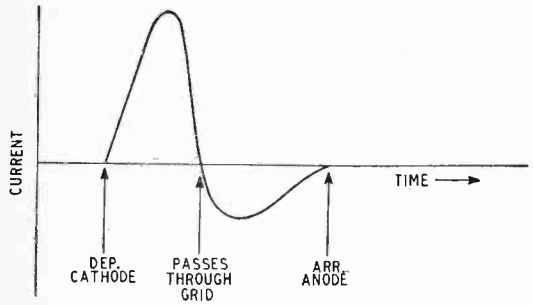


Fig. 5. An electron flying from cathode to anode through a control grid induces a grid current as shown.

it. But during the first step of an electron's journey to the anode it is moving towards the grid, so it induces a small current in the grid circuit, just as was explained in connection with Fig. 2 for the anode circuit—though the waveform is unlikely to be quite the same. After it has passed through the grid it induces a current of opposite polarity; see Fig. 5. The duration of this cycle is of course the transit time, which we have already noted is usually of the order of 10^{-9} sec. At moderate signal frequencies this is too quick for the grid potential to change appreciably, so the positive and negative portions of Fig. 5 represent equal amounts of work, and cancel out. But at very high signal frequencies the grid potential changes appreciably during the transit time and the resulting inequality of positive and negative work causes a loss in the grid circuit. This loss can be represented by a resistance. Being in parallel with the grid circuit, it is one of the things that make the net resistance low at very high frequencies. At the moment, we are not directly concerned with that; what does concern us is that this resistance depends on the rate at which electrons pass the grid, and as that varies randomly the resistance varies and causes noise.

Even at low radio frequencies one naturally uses a pentode rather than a triode, mainly for the sake of the screening it provides between grid and anode. The need for this is even greater at v.h.f. But it was soon found that at v.h.f., where noise is the limiting factor, a pentode is much noisier than a triode. This was traced to the fact that the second grid intercepts a fraction of the anode current. A row of waitresses with trays, widely spaced across the conference refreshment room, would waylay some of the delegates; each one thus intercepted would reduce the number arriving at the buffet, and thereby modulate that stream in a random manner.

It is easy to see that any current-taking grid introduces an additional random element and hence noise; but since the grid current is seldom as much as one-fifth of the whole, we might expect its noise contribution to be in that proportion and therefore not enough to worry about. But whereas the shot noise due to random emission, common to triodes and pentodes, is reduced by space charge to perhaps a tenth, there is no such luck with partition noise (as it is called). So it is usually at least double the emission noise.

I haven't left myself space to go into details about its derivation, but the rough formula for pentodes, corresponding to $2.5/g_m$ for triodes, is

$$R_N = \frac{I_a}{I_a + I_{g2}} \left(\frac{2.5}{g_m} + \frac{20\, I_{g2}}{g_m^2} \right)$$

Here the first term in the bracket is obviously the emission noise—the triode term reduced to the extent that the space current is diverted from the anode—and the second is the partition noise. Filling in values taken from data for a pentode designed for v.h.f. amplification:

$$R_N = \frac{10}{10 + 2.5} \left(\frac{2.5}{7.4} + \frac{20 \times 2.5}{7.4^2} \right)$$

$$= 0.8\ (0.34 + 0.92)\ k\Omega$$

$$= 270\Omega + 730\Omega = 1000\Omega$$

So the total is about 3 times what it would be as a triode (340Ω). That accounts for the urge to use triodes for the first stages of sensitive v.h.f. receivers, however unsuitable they appeared for the task. The first expedient to make them work there was to arrange them with earthed grid as a screen between input and output. This method has now been generally superseded by the cascode arrangement, in which a double triode secures the advantages of a pentode without its disadvantages.

At the lower frequencies it is common practice to make the first valve the frequency changer. The higher the frequency, the greater the temptation to do so, since it becomes difficult to coax amplification at the original frequency. But the signal/noise ratio of frequency changers is several times worse than that of amplifiers, so even a little r.f. amplification is not to be despised. The reason is that the effective amplification of a frequency changer is related to g_c, the conversion conductance, which is only about $\frac{1}{3}$ of g_m, whereas the noise is at least

(*Continued on page 627*)

as great; in fact, slightly greater, owing to the oscillator. The rough formula for a triode is

$$R_N = \frac{4}{g_c}$$

and for a pentode

$$R_N = \frac{I_a}{I_a + I_{g2}} \left(\frac{4}{g_c} + \frac{20\ I_{g2}}{g_c^2}\right)$$

These speak for themselves, which is just as well, for the closing bell may sound any minute.

Lastly, there are the heptodes, hexodes, etc., which can be lumped together as multi-grid frequency changers. The more current-carrying electrodes, the more noise is introduced by random partition; so valves in this class are the worst of all, and would never be chosen for the first stage of a sensitive v.h.f. receiver. The formula is

$$R_N = \frac{20\ I_a\ (Ik - I_a)}{Ik\ g_c^2}$$

where Ik is the cathode current. I suggest you look up a valve data list and work out a few values of R_N in the various classes. Remember, of course, to use consistent units—mA and kΩ, *or* A and Ω.

We have been concentrating rather heavily on the high end of the frequency scale, because that is where random noise is the thing that limits reception, and also the transit-time ingredient increases with frequency. For the sake of completeness mention should be made of flicker effect, which seems to be due to comparatively slow changes at the cathode surface causing random variations in emission. At any rate, it is important only at low a.f. and below, where it increases steeply. In badly made valves there is yet another cause of random noise: ionization, due to inadequate vacuum. Of course it inevitably occurs in gas-filled valves even when (in fact, because) they are properly made, and such valves are sometimes used as sources of random noise for testing. In case any reader is not up in the jargon, perhaps I had better mention that random noise, in so far as it is distributed equally over the whole frequency spectrum, like white light in the visible band, is often called white noise.

In brief: all valves are subject to shot noise because of random emission. In nearly all, this effect is considerably muffled by the space charge. So diodes and triodes on the whole are relatively quiet. Current carrying grids introduce further noise (partition), which is not muffled. So pentodes are usually several times worse than triodes. Valves used as frequency changers are relatively noisier than as amplifiers, because they amplify the signal about $\frac{2}{3}$ less. The order of preference of the different classes of valve in this role is the same as in the straight amplifying role. Beside shot and partition noise, which are very "white," there are grid-admittance noise which increases steeply at the v.h.f. end, and flicker noise which increases steeply at the a.f. end.

Elements of Electronic Circuits

20.—ADDITION AND SUBTRACTION CIRCUITS.

By J. M. PETERS, B.Sc. (Eng.), A.M.I.E.E., A.M.Brit.I.R.E.

MATHEMATICAL operations can be performed on waveforms, especially the square wave, with reasonably accurate results and use is made of this in the field of computation.

It is possible to carry out the operations of addition, subtraction, differentiation and integration without having to resort to valves or other non-linear devices, but accuracy is increased with the aid of the feedback amplifier. The operations of multiplication, division, squaring and the extraction of square roots (which will be dealt with later) are very difficult to perform using only linear elements such as resistor networks. Depending on whether accuracy or speed is the governing factor a choice can be made from several different methods. For example, in multiplication, electromechanical methods may give a high degree of accuracy, but if speed is desired it will be necessary to use circuits with multi-electrode valves.

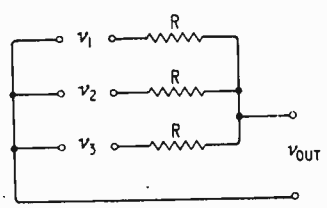


Fig.1.

Addition and Subtraction

Addition can take a number of forms and the process is met for example in (i) heterodyning in radio receivers, (ii) feedback, where a portion of the output of an amplifier is "added" to the input, (iii) a.g.c. in radio receivers, where the a.g.c. voltage is added to the bias of the earlier variable-μ stages. The simplest form of adding circuit involves linear passive elements such as the parallel-resistor adding circuit of Fig. 1.

$$v_{out} = (v_1/R + v_2/R + v_3/R)\ (R/3)$$

$$\therefore v_{out} = (v_1 + v_2 + v_3)/3$$

Inductors and capacitors can also be used in simple adding networks of this sort.

The simplest form of subtraction circuit involves a phase-reversing device such as a valve or a transformer. One of the principal drawbacks to the simple addition circuit of Fig. 1 is that at high frequencies stray capacitance effects may distort

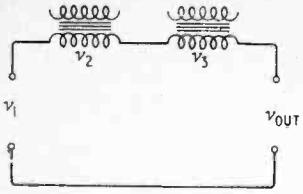


Fig.2.

the waveforms. This is overcome by inserting a small capacitor in parallel with each resistive branch and a resistor in parallel with the stray capacitances. The time constants (CR) are arranged to be the same. Series addition circuits are also used for the addition of voltage, e.g. Fig. 2 where transformers are used.

$$v_{out} = v_1 + v_2 + v_3$$

A balanced equal-arm bridge is a useful method of eliminating mutual coupling between the inputs. An example is shown in Fig. 3. Solving the mesh equations by Kirchhoff's laws it can be shown that

$$v_{out} = (Z/2)\,[v_1/(Z + Z_1) + v_2/(Z + Z_2)]$$

Difficulties are often encountered when it is desired to add voltages with short rise times such as rectangular pulses; but the method of overcoming the stray-capacitance effect described above is usually successful. Transients which produce overshooting and shock-excited oscillations can be minimized by damping and compensating networks. Waveform

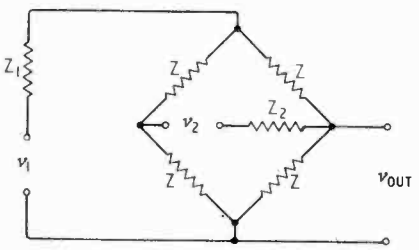


Fig.3.

shaping (described in an earlier instalment) can also be performed at the same time as addition and helps in compensating for waveform slow rise times.

Use of Valves

The use of valves in addition and subtraction circuits provides a means of isolating the network from the source voltages and for changing the impedance levels between network and source. Reasonable accuracy can be obtained by using multi-grid valves as shown in the subtraction circuit of Fig. 4.

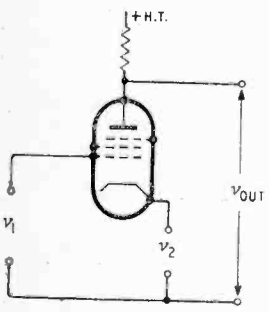


Fig.4.

$$v_{out} = v_1 - v_2$$

Note that the low input impedance at the cathode ($\approx 1/g_m$) makes it necessary to supply the cathode from a low-impedance waveform source.

Alternatively the application of signals to control and screen grids results in the output being the sum of these voltages. Sum and difference voltages

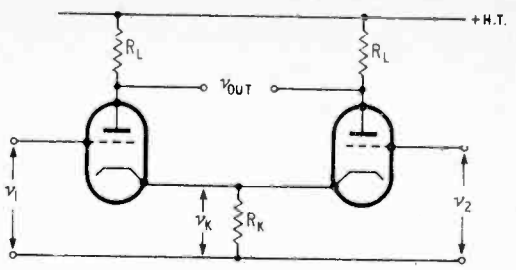


Fig.5.

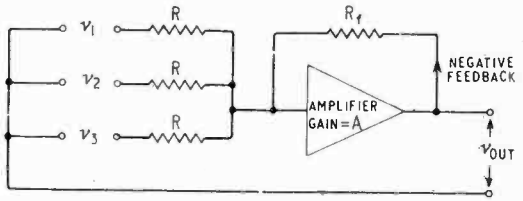


Fig.6.

may be obtained from the cathode-coupled paraphase amplifier or long-tailed pair (described in No. 5, September, 1959) (Fig. 5). The difference in voltages appearing at the anodes (v_{out}) is proportional to the difference between the inputs at the grids ($v_2 - v_1$). On the other hand, the cathode voltage, v_K, is proportional to the sum of the inputs to the grids ($v_2 + v_1$).

One of the most useful addition circuits is perhaps the parallel-addition circuit of Fig. 1 followed by stages of amplification with negative feedback (Fig. 6). This gives an output of inverted polarity, compared with the passive network. The advantages are that the amplitude of the output can exceed the input, also that with this circuit only one amplifier is necessary regardless of the number of inputs to be added.

$$v_{out} = (R_f/R)\,(v_1 + v_2 + v_3),$$

as long as the gain within the feedback loop is high. This presupposes a high value for A, the amplifier gain, and a fairly low numerical value for R_f/R, which is the overall gain of the circuit with feedback.

Commercial Literature

Thirty Transistor Circuits, covering a range of functions including a.f. amplifiers, regulated power supplies, d.c. to d.c. and d.c. to a.c. converters, oscillators and a photographic electronic-flash unit are contained in "Newmarket Transistors—Application Notes" from Newmarket Transistors Ltd., Exning Road, Newmarket, Suffolk.

Molybdenum Disulphide as a lubricant and additive to lubricating solutions can bring about reductions in wear. Booklet on molybdenum disulphide, giving data on applications, from Rocol, Ltd., Rocol House, Swillington, near Leeds.

Silvered-Mica Capacitors made by Johnson Matthey have the electrodes screen-printed, instead of sprayed, on to the mica. The makers call these "Silver Star" and claim that the sharply defined edges of the electrodes aid stability. Booklet describing the process and listing the capacitors from the manufacturers at 73-83, Hatton Garden, London, E.C.1.

Radio and Television Interference. Advice on the tracing and suppression of interference is given in a booklet called "Everyman's Guide to Electrical Interference" published by Belling and Lee, Ltd., Gt. Cambridge Road, Enfield, Middlesex.

DECEMBER MEETINGS

Tickets are required for some meetings; readers are advised, therefore, to communicate with the secretary of the society concerned.

LONDON

2nd. I.E.E.—Discussion on "Telemetering biological data" opened by Dr. G. H. Byford and Dr. K. G. Williams at 6.0 at Savoy Place, W.C.2.

2nd. Brit.I.R.E.—"Progress in microminiature circuit techniques for digital computers" by D. Roberts, Dr. D. S. Campbell and P. M. Thompson at 6.30 at the London School of Hygiene, Keppel Street, W.C.1.

7th. Institute of Physics and Physical Society.—"The international conference on physics education" by N. Clarke at 6.0 at 47 Belgrave Square, S.W.1.

7th. Brit.I.R.E.—"Flight evaluation of airborne electronic equipment" by H. G. Hinckley at 6.30 at the London School of Hygiene, Keppel Street, W.C.1.

8th. Television Society.—"The all transistor receiver: where do we stand?" by A. Landman (Plessey) at 7.0 at the Cinematograph Exhibitors' Association, 164 Shaftesbury Avenue, W.C.2.

8th. Radar & Electronics Association.—"True motion radar" by J. H. Beattie at 7.30 at the Royal Society of Arts, John Adam Street, W.C.2.

12th. I.E.E.—"Topology concepts in network theory" by Dr. P. R. Bryant at 5.30 at Savoy Place, W.C.2.

13th. Brit.I.R.E.—"Objective and subjective requirements for loudspeakers" by F. H. Brittain at 6.30 at the London School of Hygiene, Keppel Street, W.C.1.

13th. I.E.E. Graduate and Student Section.—"Electrical engineering in the Naval Service" by Sir Hamish MacLaren at 6.30 at Savoy Place, W.C.2.

16th. B.S.R.A.—"Magnetic recording in the home cinema" by D. O'C. Roe at 7.15 at the Royal Society of Arts, John Adam Street, W.C.2.

20th. I.E.E.—Discussion on "Digital transducers" opened by L. Airey at 5.30 at Savoy Place, W.C.2.

21st. I.E.E. — "Microminiaturization" by L. J. Ward at 5.30 at Savoy Place, W.C.2.

BELFAST

13th. I.E.E.—"Wave guides" by Dr. P. J. B. Clarricoats at 6.30 at the Civil Engineering Department, Queen's University, Stranmillis Road.

BIRMINGHAM

5th. I.E.E.—"Radiocommunication in the power industry" by E. H. Cox and R. E. Martin at 6.30 at the College of Technology.

BRADFORD

6th. I.E.E.—"Thermistors—their theory, manufacture and application" by Dr. R. W. A. Scarr and R. A. Setterington at 6.30 at the College of Technology.

BRISTOL

13th. Television Society.—"Ferrites in television receivers and aerials" by E. C. Snelling at 7.30 at the Hawthorns Hotel, Woodland Road, Clifton.

CHESTER

12th. I.E.E.—"The potentialities of artificial earth satellites for radiocommunication" by W. J. Bray at 6.30 at the Town Hall.

EDINBURGH

5th. Institute of Physics and Physical Society.—"Low noise amplifiers" by Dr. R. A. Smith at 7.15 at the University.

GLASGOW

6th. Institute of Physics and Physical Society.—"Low noise amplifiers" by Dr. R. A. Smith at 7.15 at the University.

HOVE

7th. I.E.E.—"Radiocommunication in the power industry" by E. H. Cox and R. E. Martin at 6.30 at 10 Queens Gardens.

LIVERPOOL

14th. Brit.I.R.E.—"V.H.F. sound broadcasting" by L. G. Dive at 7.0 at the Adelphi Hotel.

MALVERN

5th. I.E.E.—"Parametric amplifiers" by R. V. R. Carter and I. A. Bagnall at 7.30 at the Winter Gardens.

MANCHESTER

1st. Brit.I.R.E.—"Industrial television" by I. M. Waters at 7.0 at the Reynolds Hall, College of Technology.

7th. I.E.E.—Discussion on "New semiconductor devices" opened by A. A. Shepherd at 6.15 at the Engineers' Club.

21st. I.P.R.E.—"Control systems" by J. Pyke at 7.30 at Central Hall, Oldham Street.

NEWCASTLE-UPON-TYNE

5th. I.E.E.—"Radar observations of birds and 'angels'" by Dr. E. Eastwood at 6.15 at the Rutherford College of Technology, Northumberland Road.

7th. Brit.I.R.E.—"Human engineering" by S. G. Ramsay at 6.0 at the Institution of Mining and Mechanical Engineers, Neville Hall, Westgate Road.

NEWPORT, I.O.W.

9th. I.E.E.—Discussion and demonstration of stereophonic sound at 6.30 at S.E.B. Showrooms.

NORWICH

6th. I.E.E.—"Engineering aspects of commercial television programme presentation" by T. C. Macnamara at 7.30 at the Assembly House.

READING

15th. Institution of Production Engineers.—"Electronic data processing allied to production engineering" by F. W. Purchall at 7.30 at the George Hotel, King Street.

SOUTHAMPTON

6th. I.E.E.—"F.M./A.M. v.h.f. portable transistor receivers" by L. E. Jansson at 6.30 at the University.

14th. Brit.I.R.E.—"Some new piezoelectric devices" by A. E. Crawford at 7.0 at the University.

STONE

12th. I.E.E.—"Recent developments in colour television" by I. J. P. James at 7.0 at Duncan Hall.

SWANSEA

13th. I.E.E.—Faraday Lecture on "Transistors and all that" by L. J. Davies at 6.30 at the Brangwyn Hall.

WORKINGTON

13th. I.E.E.—"The transmission of news film over the transatlantic cable" by C. B. B. Wood and I. J. Shelley at 7.0 at the College of Further Education.

RANDOM RADIATIONS

By "DIALLIST"

Far-East Colour TV

SO Japan, or at least Tokyo and Osaka, has a colour television service. The man who after a three-year struggle forced a reluctant government to make up its mind on the subject is said to be Mr. Matsutaro Shoriki, president of Nippon Television (NTV), who got the country's 525-line black-and-white service started in 1953. Ordinary television has become so popular in Japan that all but the very poorest now have receivers and the total is over six million. Mr. Shoriki is firmly convinced that there will be a similar boom in colour TV. To get things going he put up colour receivers in various public places. The system used is the N.T.S.C. and it is reported that the Japanese have improved upon the results obtained in the United States. They have apparently not succeeded in developing low-priced domestic receivers; but even though the earnings of factory and other workers are much less than they are in America, Mr. Shoriki is convinced that colour sets will sell. Japan, it appears, is well provided with "never-never" facilities.

What About Us?

After five years of experimental colour transmissions the B.B.C. has announced that, technically at any rate, it is ready to start a regular service, if and when permission is given. The radio industry doesn't feel that the time is yet ripe, for no manufacturer in his senses—and ours are very much in theirs—wants to go into the production of colour receivers unless there is likely to be a good demand for his wares. The big snag is the cost of the receiver, governed largely by the cost of the three-colour tube, and, frankly, I don't think that our people would go for them in a big way unless this can be greatly reduced.

DX Printing

THE setting of the type of the New York and Paris editions of the *New York Times* simultaneously is a very remarkable feat. The Paris edition now goes to press at the same time as the early edition in New York. The setting is done by a tape perforated by means of wireless signals—the transatlantic cable will be used if radio conditions are bad—which is fed into linotype machines. Naturally some of the type-setting will be done in the ordinary way in Paris, for purely local American news won't be carried in the French edition, the space being devoted to happenings on this side of the Atlantic. Many of the advertisements will be different. Owing to the time difference—Paris is six hours ahead of New York—the Paris issue must derive from a very early American edition. But, of course, the U.S.A. is a large country and very early editions are needed if the paper is to appear on distant breakfast tables.

Anti-mortar Radar

IN collaboration with the Royal Radar Establishment, E.M.I. have developed a new type of radar equipment for which substantial contracts have been placed by the War Office and by the Swedish army. This equipment enables mortar shells or bombs to be tracked in flight and makes it possible to calculate accurately and quickly the exact position from which they were fired. It is small and highly mobile and is said to be very easy to operate. Something of the kind was done towards the end of the last war with ordinary radar sets. They were used to spot shells as they left an enemy battery and proved very useful in Italy for pin-pointing hostile battery positions with considerable accuracy.

I.G.Y. No. 2

THERE are plans afoot, I see, for holding a second International Geophysical Year on a smaller scale at the time of the next sunspot minimum, which is due to come along in about four years' time. The idea is that we can get to know a good deal more if we compare the happenings recorded during a period of maximum solar activity with those which occur when such activity is at a minimum. An excellent scheme and may it have the success it deserves. Completely satisfactory explanations of some of the phenomena of I.G.Y. No. 1 haven't so far been found and the second series of observations may help to clear things up.

TV Progress in France

AT long last television seems to be really getting into its stride in France. At the end of June this year the total of "declared" sets had risen to 1,700,000. And there's pretty sure to be a largish number of undeclared, or pirate receivers, as undoubtedly there is in this country. The French transmitter, booster and relay net-

work is not yet complete and where transmissions have only recently begun the increase in the number of viewers has so far proved surprisingly slow. And that is unfortunately true of certain other regions which have had a service for some time. Alsace, for instance, can boast only 28,900 receivers, though the Strasbourg transmitter has been at work ever since TV began in France.

Bigger and Bigger

THEY like big things in the U.S.A. and whatever sized TV screen comes along there's always a demand for something a bit larger. Having introduced 27-inch sets comparatively recently some of the manufacturers now have plans for 29-inch sets. I'd have thought that the best way of getting a really big picture would be to make use of projection techniques. But that doesn't seem to have caught on over there any better than it has done here. Talking of screen sizes reminds me of a conversation between two fishermen that I overheard on a boat not long ago:

"How big's your TV set?"

"Fourteen inches."

"Oh, you want something bigger than that."

"Does me all right."

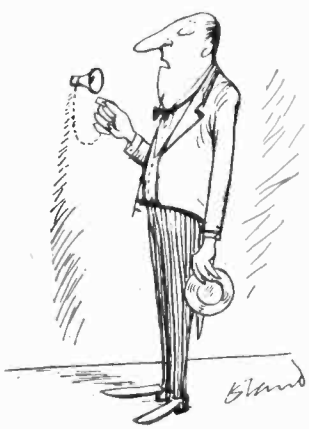
"But don't you see you're missing a lot of the picture."

"How do you mean?"

"Stands to reason. A screen of that size isn't big enough to take the whole picture that's sent out. The same sized picture is sent to everyone; but if your screen is small, some of it laps over the edges and you can't see those bits."

"Oh, I hadn't thought of that."

Frankly, I hadn't either!



Roger and Out, Sir.

UNBIASED

By FREE GRID

Unlicensed Sets

HOW many unlicensed sets are there in this country? I am told that a recent industrial survey covering car radio showed that only about 50% of the sets were licensed. It does not surprise me in the least to hear this opinion, and I think the proportion in the case of domestic sets is fully as bad.

Look for example, at the numerous houses which are let out in what are euphemistically called one-room flats. In these days of miniaturized transistor sets, I wonder how many of the tenants—some of whom are very transient—bother about a licence? I would go even further and say that in a great many cases the owners of these sets think that the licence—if any—of the landlord covers them.

When a householder changes his address he can fill in a form for letters to be redirected and one of the questions asked on the form is for particulars of his wireless licence, if any. If he has no licence he is asked to write "None." The non-licence holder can write "None" with a perfectly clear conscience; at any rate that part of his conscience which deals with truth-telling will be clear, if, indeed, a conscience can be compartmented, as so many people obviously think, judging by their behaviour. It would seem to be more useful to ask if the form-filler had a receiver, but there would, of course, be little point in it unless it were made an offence to give a false answer.

But all the same, the very fact of a person having to fill in particulars of his licence or else write "None" might have the same psychological effect on a guilty conscience as does the presence of a G.P.O. wireless detector van in the neighbourhood.

Even so, only the householder is affected because it is clearly stated in the Post Office Guide (July, 1960 edition, page 67) that the P.M.G. will not undertake to re-direct the correspondence of those in lodgings, etc., and therefore, the people whom I regard as the real offenders, namely sub-tenants or lodgers, do not receive even the psychological stimulus of answering the questions about licences on the mail redirection form.

I am quite aware a G.P.O. inspector has authority to call at any time and inspect the wireless installation *of a licence holder*. But he certainly can't demand entrance to the home of a non-licence holder but must apply to a Justice of the Peace for a search warrant, after first satisfying the J.P. that he has reasonable grounds for suspicion. But Section 15 of the Wireless Telegraphy Act of 1959 only mentions a search warrant for premises. It makes no mention of a search of the person of a suspect which would, therefore, be *ultra vires*. In these days of tiny transistor sets, a radio receiver can easily be concealed in a man's pocket, or even in the corsage of a lady's dress. If an over-zealous Post Office official dared to search in the latter place, he would find himself on very dangerous ground indeed. Supposing the lady in her haste to conceal the set had inadvertently knocked the switch to the "on" position, it would be very galling but singularly apt if, as the perspiring official searched the room, the strains of "Music While you Work" burst forth from the depths of her person. He could only gaze at her in baffled impotence, knowing full well that he dared not search her. It would be truly an apoplectogenic situation.

At one time the outdoor aerial made it obvious when a TV set was installed but in these days more and more indoor aerials are in use, and before many years have gone by, we shall all be using sets with built-in aerials.

Could not a question about wireless licences be included in the census form which we shall all have to fill in on April 23rd next, or better still, could not such a question be put in the form which we all receive annually for the compilation of the electoral roll.

In my opinion, if every person who *ought* to have a licence did, in fact, have one, the B.B.C.'s revenue would be increased considerably.

Cymatology

RECENTLY, when reading an interesting article by a learned professor who is also a Fellow of the Royal Society, I was a little surprised to find that when he mentioned electromagnetic waves, he appended in parentheses the explanatory words, "light waves or radar waves." It was at once clear to me that he was not writing for his peers, who would naturally not need to be told what electromagnetic waves do for a living; nor, I realized, could he be writing for people having a slightly lesser standard of knowledge, possessed, for instance, by those who have only just matriculated in *Wireless World* readership.

It was only after further thought that it suddenly dawned on me that the writer (Professor J. L. Synge) had chosen the words "radar waves" with that careful and precise thought which one associates with an F.R.S., and that he may have intended it as an indirect rebuke to all those of us who use the vague and unsatisfactory word "radio" in such phrases as "radio receiver" and "r.f. amplifier."

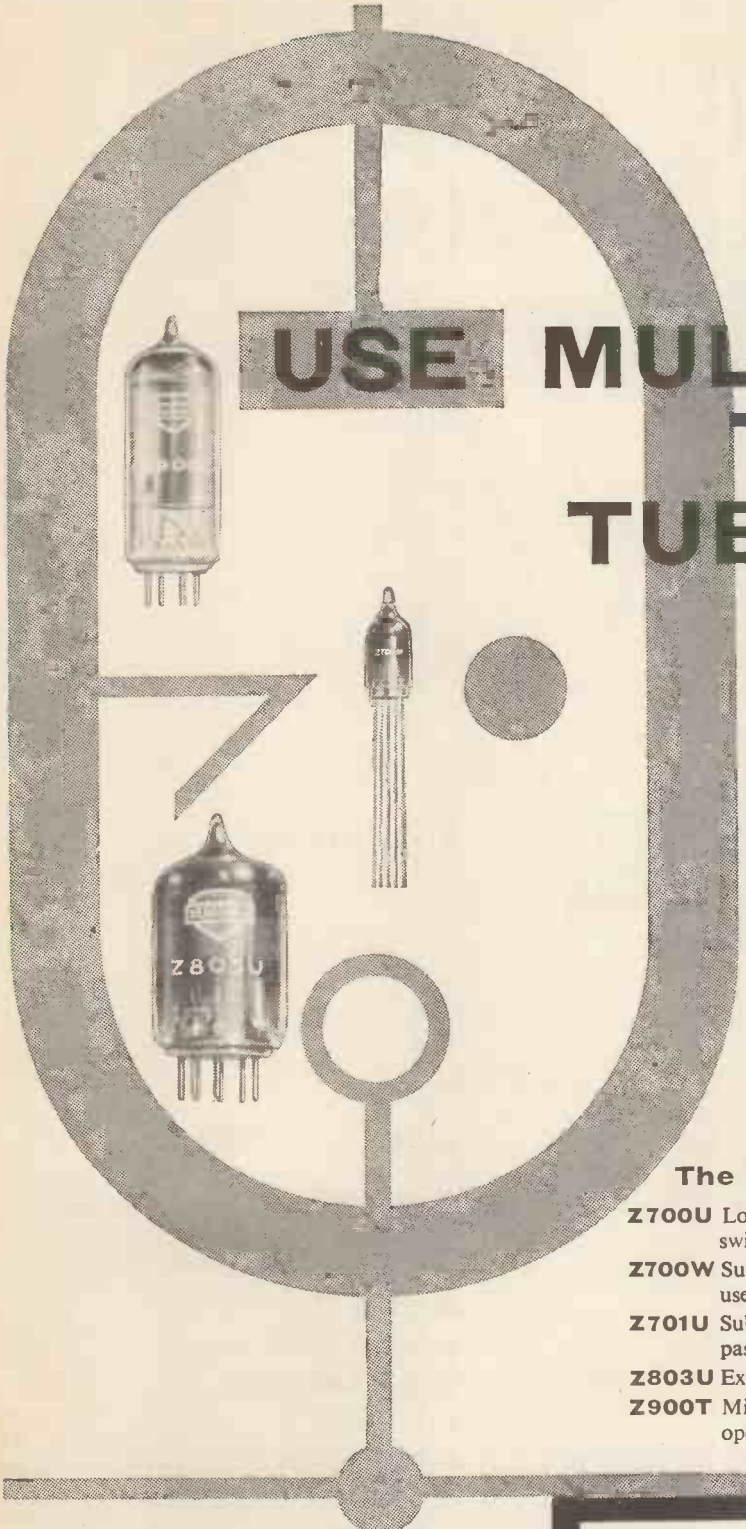
When all is said and done, the true definition of a radio wave is one which is radiated *in any medium*. There is nothing to restrict the word radiation (and, therefore, radio) to the electromagnetic spectrum except customary usage or, more correctly, misusage; if that be allowed to influence us we cannot cavil at the great majority of our fellow citizens who misuse the lovely old English abbreviation "ain't," and pervert it from its true meaning.

It is clear that electromagnetic waves are merely a subdivision of radiated waves (or, in other words, of radio waves). Sound waves also are undoubtedly radiated and, in like manner, if we drop a stone into a pond, do we not bring about the radiation of surface waves in the water in ever-widening circles? The O.E.D. lends support to my views as it tells me, *inter alia*, that radiation is "the manner in which the energy of a vibrating body is transmitted in all directions by a surrounding medium"; it does not define the medium.

The word "radar" which the professor uses has a very clear and precise meaning, for it was synthesized from the initial letters of words defining a particular application of e.m. waves, and has nothing to do with the altosonic or supersonic waves which bats use for a similar purpose.

Searching for my stud with e.m. waves.

We ought, therefore, to rename our radio receivers, and also cease to talk of an r.f. amplifier. But we must be careful not to adopt the name e.m.w. receivers for, obviously, that could equally well mean a camera, and it would certainly lead to confusion if we spoke of an e.m.f. amplifier even though the set-up which we call an r.f. amplifier is, in fact, a voltage amplifier. I do feel that only a person with the precise mind of an F.R.S. could help us straighten out our nomenclature; but probably some of you may have some good ideas?



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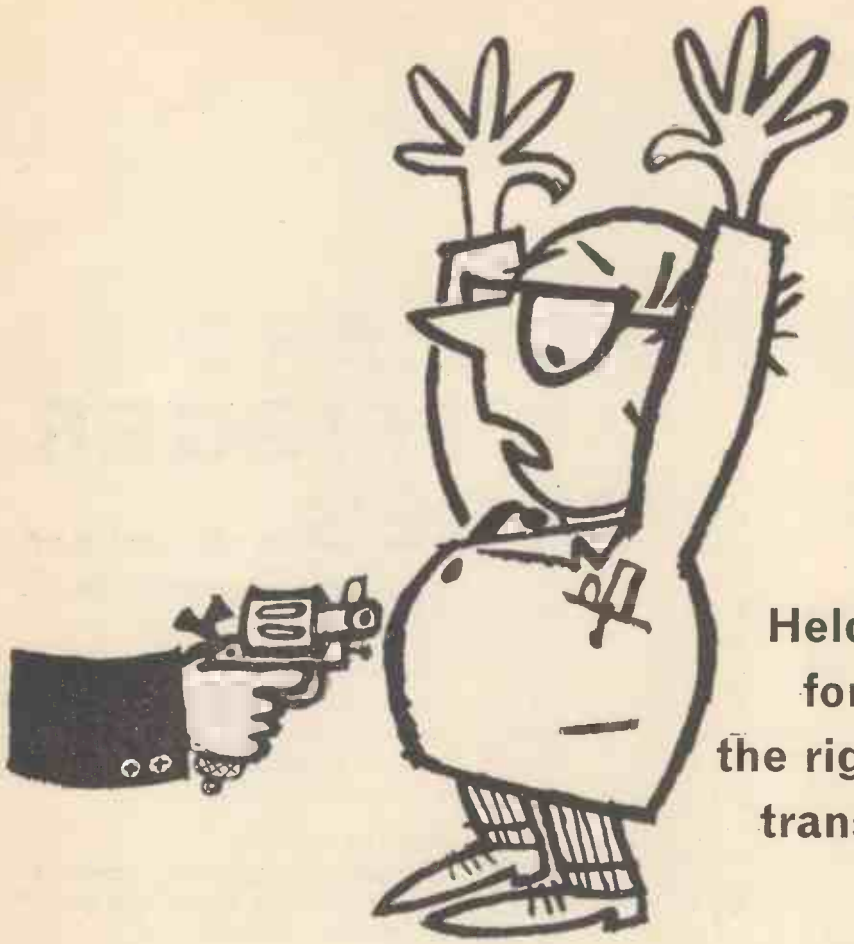

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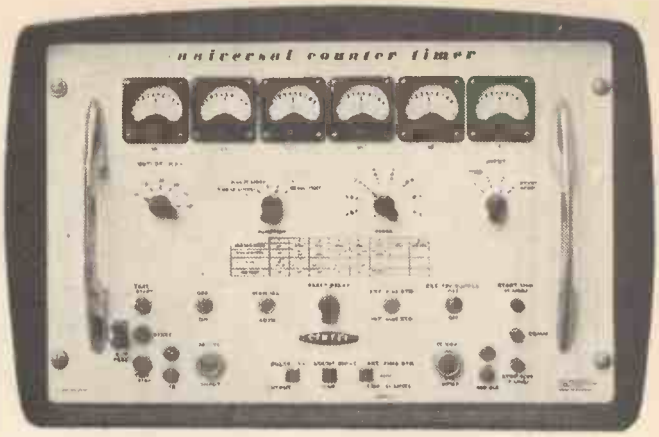

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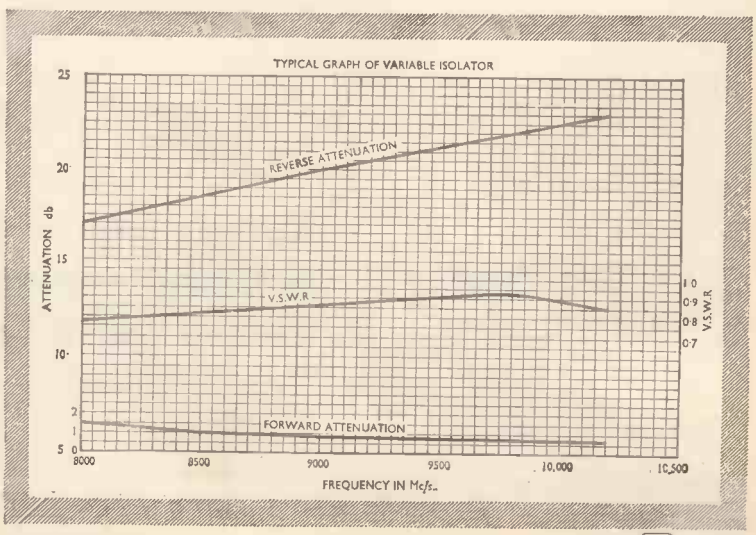

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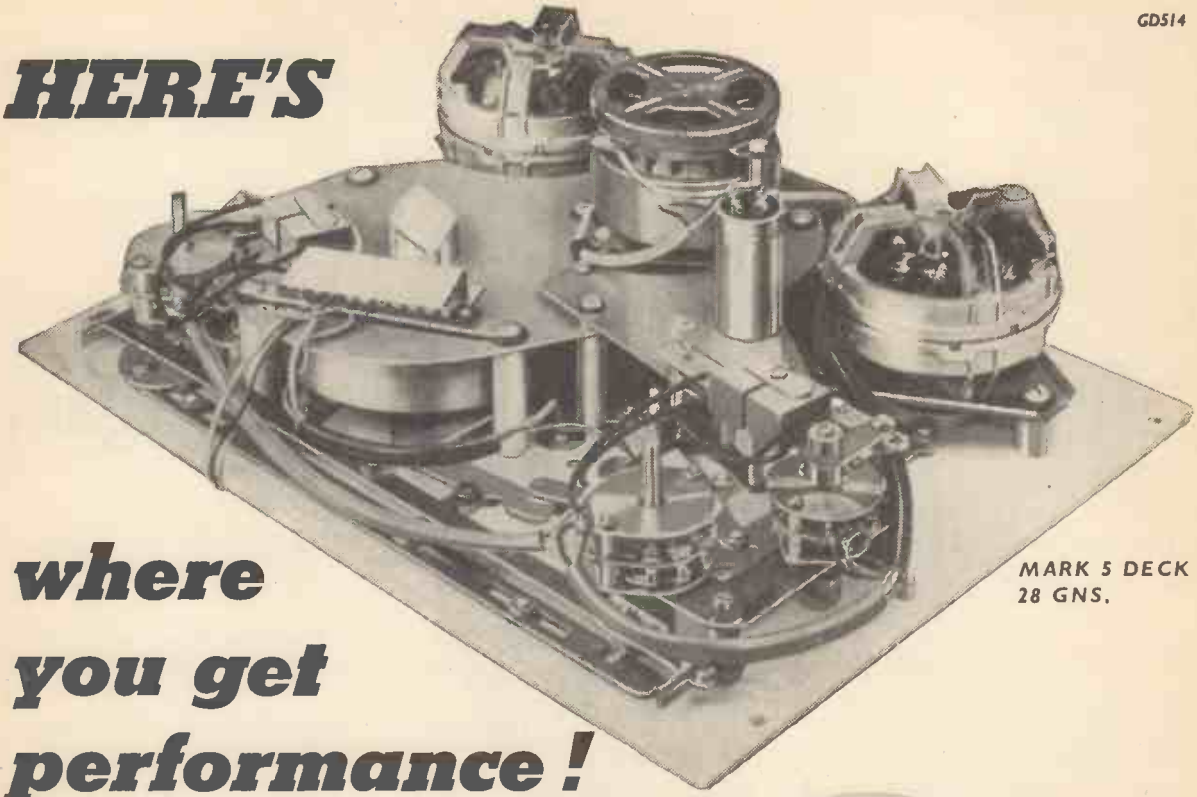

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FAST REWIND in either direction. 1,200ft. reel rewound in 45 seconds.

WOW AND FLUTTER	FREQUENCY RANGE:
Below .05% at 25 ips	15 ips: 50/16,000 c/s ± 3db
Below .1% at 7½ ips	7½ ips: 60/12,000 c/s ± 3db
Below .15% at 3¾ ips	3¾ ips: 60/7,000 c/s ± 3db
Below .25% at 1⅞ ips	1⅞ ips: 60/4,000 c/s ± 3db

SELECTIVE FREQUENCY CORRECTION at 15, 7½ and 3¾ ips. ACCEPTS 8½in. REELS. PAUSE CONTROL. DIGITAL REV. COUNTER. PROVISION FOR EXTRA HEADS.

TAPE RECORDERS:

3 STAR. 58 GNS. MK. 5. 64 GNS.
3 STAR. R/P STEREO. 89 GNS.
MK. 5 R/P STEREO £99 . 12 . 0

* ¼ track available with 3 Star models

Brenell

Full details and the address of your nearest stockist from the Sole Manufacturers

BRENELL ENGINEERING CO. LTD. · 1a DOUGHTY STREET · LONDON · WC1

CHANCERY 5809 & HOLBORN 7358

STC 4300 RANGE OF HIGH STABILITY CARBON FILM RESISTORS

The 4300 range of carbon film resistors is available where a reliable high stability close tolerance resistor is required for use in critical circuits.

The range comprises five main groups—$\frac{1}{10}$ W., $\frac{1}{2}$ W., $\frac{1}{4}$ W., $\frac{1}{8}$ W., and 1 W. Within the limits listed below resistors are available in all preferred values. Other values can be supplied to Order.

4302 1 WATT-RESISTANCE 10 Ω to10M Ω ± 1%

4303 $\frac{3}{4}$ WATT-RESISTANCE 10 Ω to 7·5M Ω ± 1%
(approved to RC2.C of RCS.112 from 10 Ω to 1M Ω)

4304 $\frac{1}{2}$ WATT-RESISTANCE 10 Ω to 5·1M Ω ± 1%
(approved to RC2.D of RCS.112 issue 2 from 10 Ω to 1M Ω)

4305 $\frac{1}{4}$ WATT-RESISTANCE 4·3 Ω to 4·7M Ω ± 1%
(approved to RC2.E of RCS.112 issue 2 from 10 Ω to 1M Ω)

4307 1/10 WATT-RESISTANCE 10 Ω to 470K Ω ± 5%

Send for Data Sheets CFR

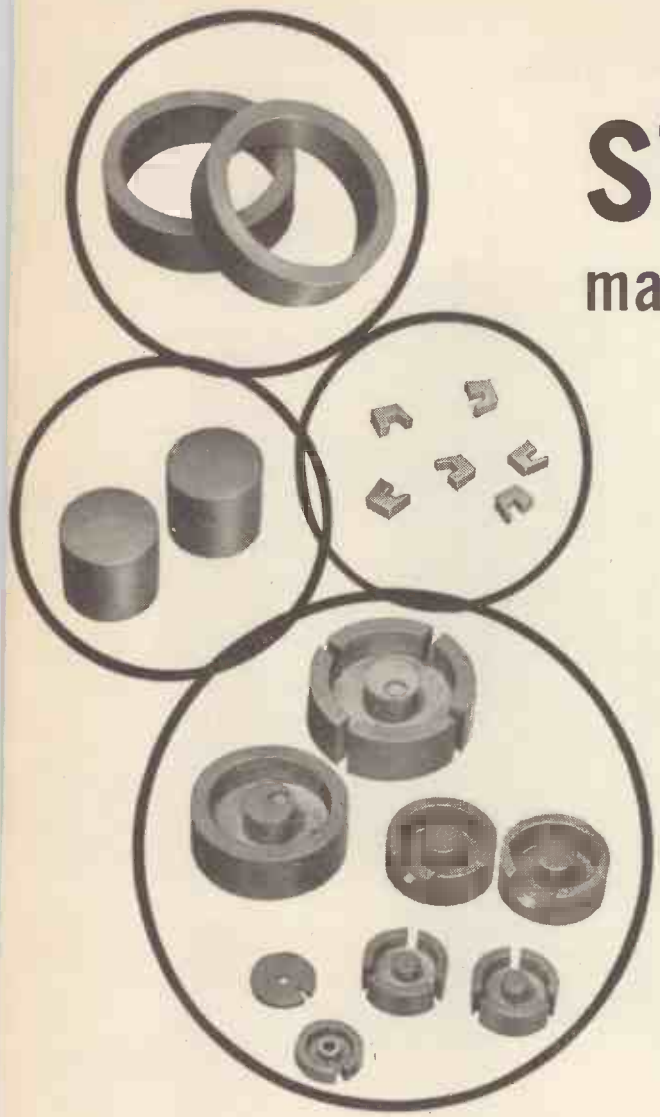
STC COMPONENTS GROUP

Standard Telephones and Cables Limited

Registered Office: Connaught House, Aldwych, London, W.C.2

RECTIFIER DIVISION: EDINBURGH WAY · HARLOW · ESSEX

60/9MF



stanferite

magnetic materials

from **STC**

PERMEABILITY RANGE FROM 15 to 2500

'Stanferite' is the latest magnetic material to be added to the already well known STC range of Permalloy powder, strip and Permendur products.

'Stanferite' is a non-metallic material having high resistivity with consequent low eddy-current losses. This characteristic enables it to be used at much higher frequencies than was previously possible with metallic materials of similar permeability.

'Stanferite' can be supplied in the form of pot cores, cylinders, rings and "U"-shaped pieces to meet most applications.

Material	Initial Permeability	Frequency range of application	Typical applications	Typical Core Shapes
			(Manganese Zinc Ferrites) — both of which have high permeability and low-loss at frequencies up to 1 Mc/s.	
S.F.1	2 000 to 3 000	Up to 1 Mc/s	Wide band and Miscellaneous Types of Transformers	"U"
S.F.15	1 100 to 1 900	Up to 1 Mc/s	High quality Inductors, Communication Transformers, Delay Lines and Recording Heads.	Pot
			(Mixed Ferrites)—having substantially rectangular hysteresis loops and therefore eminently suitable for data-processing applications.	
S.F.3	100	Pulse		Small Toroid and Magnetic Cell
S.F.11		"	Memory Arrays and Switching for Data Processing.	
S.F.14		"		
			(Nickel Zinc Ferrites) — having extremely low eddy-currrent and dielectric losses rendering them useful over a very wide frequency range up to 150 Mc/s.	
S.F.4	650	50 kc/s to 2 Mc/s		
S.F.5	250	200 kc/s to 5 Mc/s		Toroid, "U" Pot and Cylinder
S.F.6	100	500 kc/s to 15 Mc/s	H.F. Transformers and Inductors, Tuning Coils, Saturable Reactors.	
S.F.7	30	1 Mc/s to 50 Mc/s		
S.F.8	15	10 Mc/s to 150 Mc/s		

Write or telephone for Technical Data Sheets to:—

COMPONENTS GROUP

60/4MM

Standard Telephones and Cables Limited

Registered Office: Connaught House, Aldwych, London, W.C.2

MAGNETIC MATERIALS SALES DEPT: EDINBURGH WAY · HARLOW · ESSEX

RELIABLE PERFORMANCE
demands
STC COMPONENTS

The standard of reliability of STC components is set by the vital roles of the navigation and communications equipments in which many of them are used. The consequent employment of top grade materials and high degrees of skill and care in manufacture ensures that all users of STC components may have the fullest confidence in them.

YOU CAN RELY ON STC COMPONENTS

Brimistors · Capacitors · Contact Cooled Rectifiers · Ferrites · Germanium Diodes · Germanium Photocells · Hermetic Seals · High Stability Resistors · Magnetic Materials · Quartz Crystals · Relays · Special Valves · Selenium Rectifiers · Silicon Rectifiers · Silistors · Suppressors · Transistors · Thermistors · Transformers · Zener Diodes

Get to know the range of STC Components—write for booklet M/103 which lists all components and their relevant technical literature.

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60/3M

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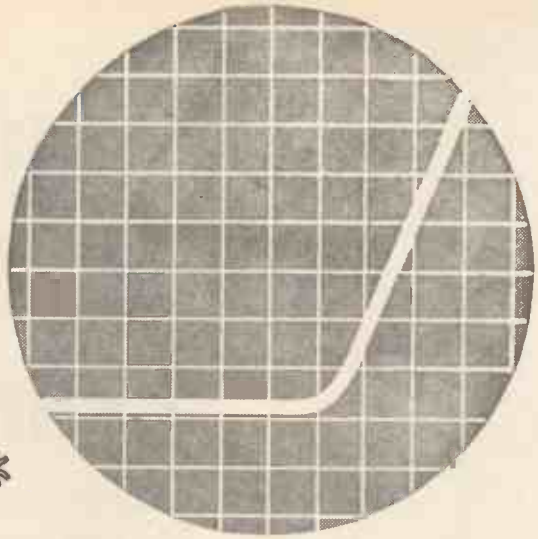


"Well, what's so **special** about that?"

DEFINITION

"O.K.—it's an ordinary characteristic but what isn't so ordinary is that we have got definition of this valve's performance. Definition in a special way that is. For instance, we know just what 'spread' we can expect in every batch that is delivered, and we have an indication of the spreads that we can expect over life.

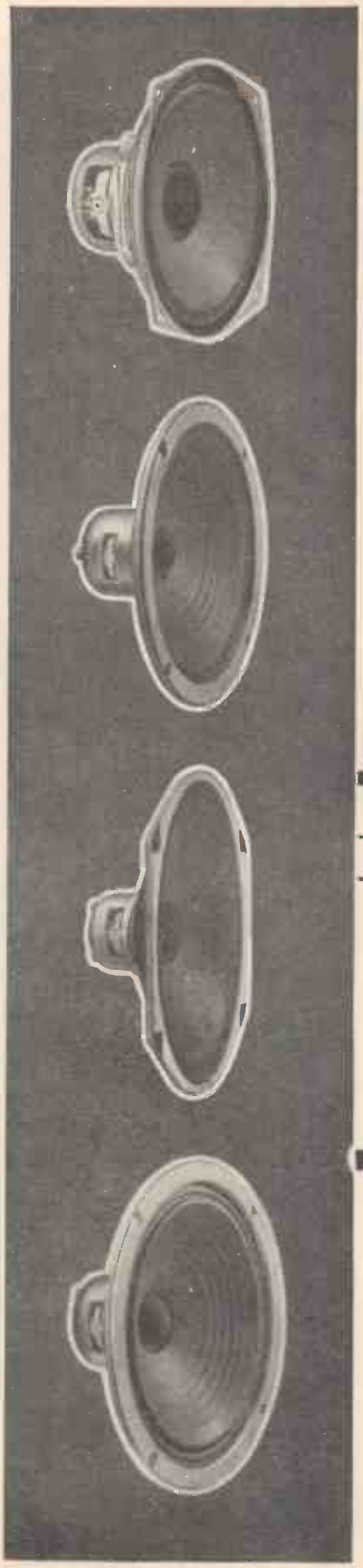
This information is a tremendous help when you're designing equipment that's *got* to be reliable and you get it on Mullard Special Quality valves. You get this information because of the work they put in at their quality and test laboratories; with it you can design circuits that allow for possible valve variations and so achieve standards of equipment dependability that might otherwise not be possible.

Closely controlled characteristics are a feature of some Mullard Special Quality valves—others have a particularly long life expectation and some are designed for application where physical shock and vibration are likely to be experienced; some even have a combination of these features."

"When it comes to selecting the right valve for the right job, you know, the people at Mullard House are very helpful—they can give you all the facts you need and what's more they're always happy to discuss problems with you."

Mullard Limited Government and Industrial Valve Division, Mullard House, Torrington Place, London, W.C.1. Telephone: LANgham 6633.

MVTA381a



POPULAR REPLACEMENT SPEAKERS

For the guidance of the trade and public we publish below a list of the most popular ELAC replacement loudspeakers.

We have made this selection from our wide range of speakers as they cover practically all the requirements of the replacement trade.

The new prices are now operative.

POPULAR REPLACEMENT MODELS

Type	Ref	Flux	Retail Price	Purchase Tax
5in.	5G	6500 g	20/6	6/7
6½in.	6G	6500 g	21/6	6/11
7 x 4in.	47G	6500 g	20/6	6/7
7 x 3in.	37G	6500 g	20/6	6/7
8 x 3in.	38G	6500 g	20/6	6/7
8 x 5in.	58C	8500 g	24/6	7/10
8in.	8C	7000 g	25/6	8/2

All loudspeakers have Standard 3 Ohm impedance. Higher impedances can be supplied at an extra cost of 3/- plus 1/- Purchase Tax.

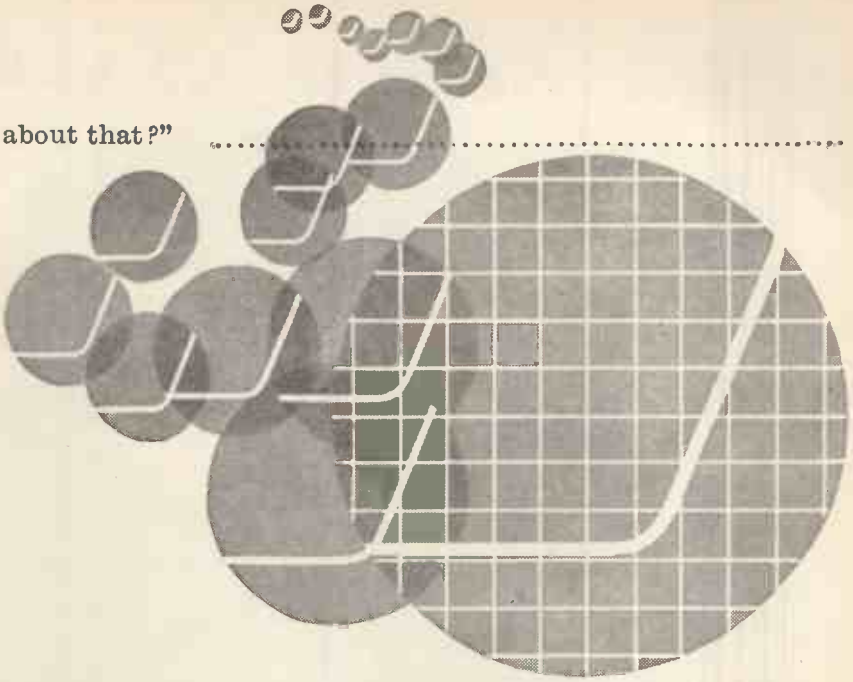
Please write for leaflets and further details.

ELAC

ELECTRO ACOUSTIC INDUSTRIES LIMITED

Stamford Works, Broad Lane, Tottenham, N.15 Tel: TOTtenham 0505

"Well, what's so **special** about that?"



LONG-LIFE

"It's a valve characteristic that looks no different from many others—what *is* special is that it will be maintained for a much greater period than you would normally expect.

This feature of long consistent performance is typical of many of the Special Quality valves they make at Mullard. They achieve these standards by combining sound design with first class materials and, of course, thorough testing. In a single year, Mullard carry out something like 30 million valve hours of life testing on these types. Obviously, the many valves used are subsequently destroyed.

You can see that with this kind of background, equipment manufacturers—and users—can specify Mullard long life Special Quality types and be pretty sure that they won't be caught out by valve failures. And that's important nowadays when so much equipment serves vital functions where failure can mean real trouble.

Long life is only one feature of the Mullard Special Quality range; there are types available with closely controlled characteristics and others are particularly rugged, some even have a combination of these features."

"Mullard, as you probably know, are most helpful when it comes to selecting the right valve for a particular job—the data they can let you have really is comprehensive and the people at Mullard House are always happy to discuss problems with you."

Mullard Limited
Government & Industrial Valve Division
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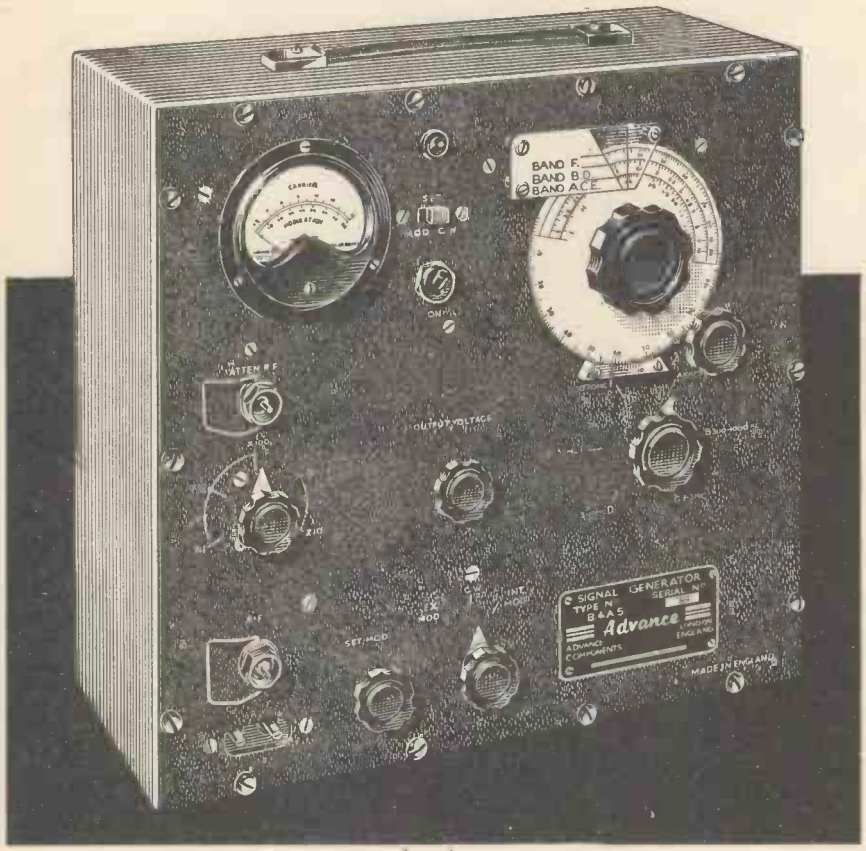
MVTA 405A

The R.F. SIGNAL GENERATOR . . .



TYPE B4

MODEL A

100 kc/s to 80 M/cs
in 6 bands

MODEL B

30 kc/s to 30 Mc/s
in 6 bands.

Calibration accuracy of both models is ± 1%

by **Advance**

to be sure!

NETT PRICE IN U.K.

£72

Full technical details in Leaflet W38 available on request.

The " Advance " B4 Signal Generator is a well tried and proven instrument which incorporates special features consisting of a monitored r.f. output and variable modulation depth (which is also monitored); an 80 dB attenuator of special design provides exceptional accuracy of attenuation throughout the frequency range and an unusually low leakage factor is achieved by triple screening of the r.f. oscillator, and by mounting the calibrated dial on the outside of the case.

OUTPUT IMPEDANCE: 75 ohm unterminated; (50 ohm model available on request) termination pad supplied to provide output impedances of 37 and 10 ohms and a dummy aerial facility.

INTERNAL MODULATION: 400 c/s ± 10%. Modulation depth 0 to 80% ± 10%.

EXTERNAL MODULATION: Model A: 10 c/s to 30 kc/s; modulation depth 0 to 80%.
Model B: 10 c/s to 10 kc/s; modulation depth 0 to 80%.

AUDIO OUTPUT: 0 to 10 volts into 600 ohms at 400 c/s.

R.F. LEAKAGE: Less than 1 microvolt.

Advance COMPONENTS LIMITED

INSTRUMENTS DIVISION

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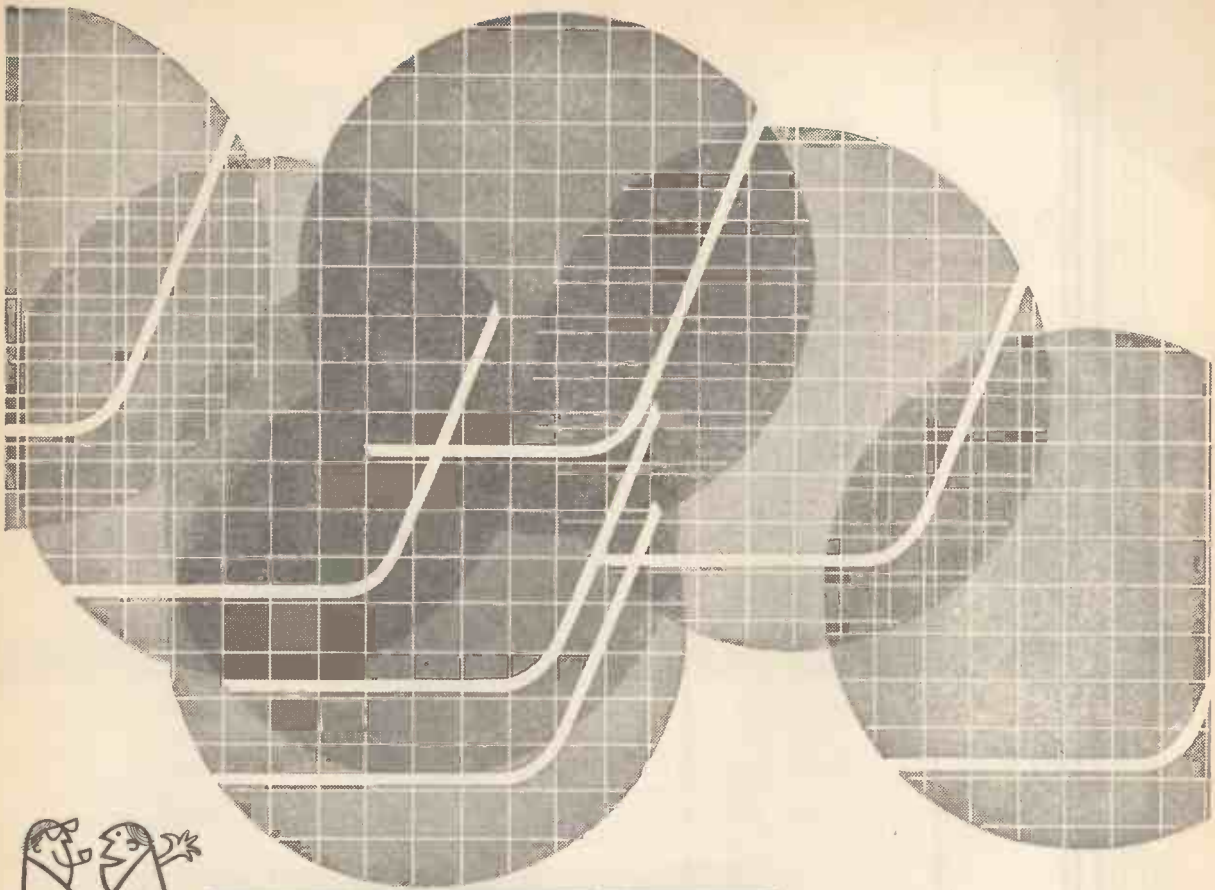
GD70



"Well, what's so **special** about that?"

RUGGEDNESS

"Yes it's a straightforward enough valve characteristic, but it *is* special because it will be maintained in spite of the punishment—shock and vibration—it will get in the equipment where it is installed.

You see, right the way through Mullard Special Quality rugged types are designed and built to the tightest specifications—tolerances are finely controlled, assembly methods are extremely accurate and welding techniques are of the highest standards. Indeed all the staff who work on them are carefully selected and specially trained—even completely new manufacturing techniques have been devised to make sure that the end product is as rugged as possible.

When it comes to equipment that must stand up to a certain amount of shock and vibration these Mullard Special Quality valves are just the job—a worthwhile insurance against valve failure and resulting equipment breakdown, with the high servicing costs that go with it.

Ruggedness is only one feature of the Mullard Special Quality range; there are types available with extra long life expectation and others with closely controlled characteristics, some even have a combination of these features."

"So far as information is concerned, Mullard can let you have all you need on any particular valve type. What's more, the people at Mullard House, who are pretty knowledgeable on these things, will always help in selecting the best valve for a particular job."

Mullard Limited

Government & Industrial Valve Division,
Mullard House, Torrington Place, London, W.C.1
Telephone: LANgham 6633

OC28

A NEW TRANSISTOR DESIGNED FOR D.C. CONVERTER APPLICATIONS

OC28

Progress in one of the most promising fields of transistor application—d.c. converters—has been delayed not by a shortage of power transistors, but by transistor avalanche breakdown caused by the simultaneous heavy currents and high voltages encountered in inductive circuits.

Now, after extensive application work and customer consultation, Mullard introduce the OC28—a transistor designed and tested for use in 28-volt d.c. converter and similar applications where inductive loads are employed.

The OC28 is dynamically tested to withstand 60 volts at 0.5 amp and 60 volts at 6 amps. This testing is additional to the normal static voltage ratings of 80 volts collector to base and 60 volts collector to emitter under cut-off conditions.

The assurance of specially controlled and specified avalanche breakdown characteristics broadens scope for the design of nominal 24 volt power converters, even where the actual supply voltage rises on occasions to 30 volts or more. For operation in self-oscillating circuits a tight control on current gain is exercised.

In static and mobile equipments—in road, rail, sea and air-borne applications—the generation of high voltage for lighting, instrumentation, communication and control is now possible. The performance and small size attainable are exemplified by a pair of OC28's mounted on a folded blackened $\frac{1}{8}$ in. thick copper plate of area $3\frac{3}{4}$ in. x 14 in. Operated from a 28 volt supply in a push-pull circuit utilising two small transformers, they will deliver 100 watts at 195 volts d.c. with an overall efficiency of 86% in ambient temperatures up to 80°C.

Please write on your company letterhead for data sheets and any further information on the OC28.

Abridged Data

V_{cb} max. (I_e=0)	—80V
V_{ce} max. (cut-off)	—60V
V_{ce} max. (I_c=0.5A)	—60V
V_{ce} max. (I_c=6A)	—60V
I_c max.	6A
P_{tot} max. at 45°C mounting base temperature	30W
T_j max. (continuous rating)	90°C
T_j max. (intermittent rating, 200 hours max.)	100°C
$\bar{\alpha}'$ (at V_c = —1V, I_e = 1A)	20 to 55
$\hat{\alpha}'$ (at V_c = —1V, I_c = 6A)	15 to 30

Mullard

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industrial semiconductors

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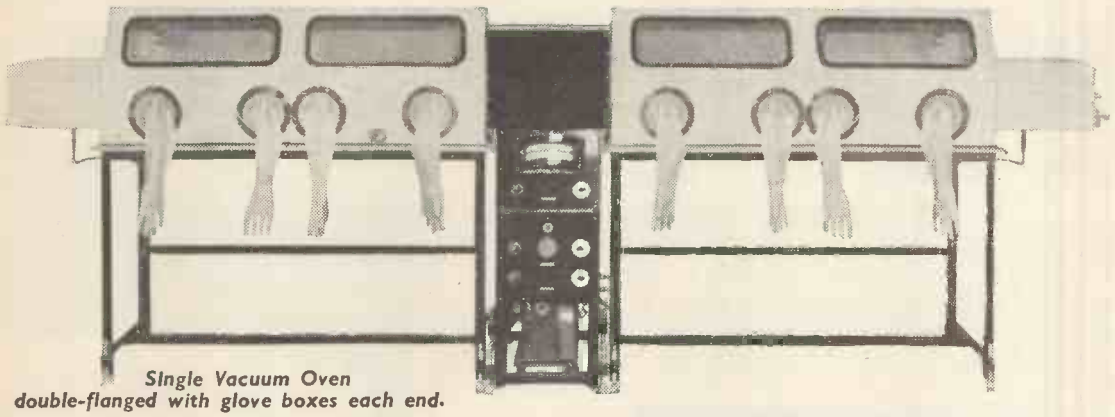
MIS24a

DOUBLE ENDED STAINLESS STEEL VACUUM OVENS



Single Vacuum Oven double-flanged with glove boxes each end.

- ★ Made throughout in polished stainless steel.
- ★ Single action door openings.
- ★ Rectangular with shelf spacings to suit.
- ★ Double ended controls.
- ★ Electrical interlocking of air inlet and isolation valves.
- ★ Outer cover hermetically sealed.
- ★ Temperature range 0°-300°C or equivalent F.
- ★ Temperature Control: Normal ±7½°C. Special ±1C.
- ★ Internal Spacing 7in. x 8in. x 18in. (can be altered to special requirements).
- ★ Vacuum Range: To 10-4.
- ★ Respective Vacuum Gauges incorporated.
- ★ Automatic air inlet valve on Backing Pump.
- ★ Visual indicators and fuses on all switches.
- ★ Flanged for fitting into Dry Box.

View showing automatic interlocking of unloading compartment on glove box.

Vacuum Oven with glove box.

We design and manufacture Ovens to Customers' special requirements. Should you have any problems in this field our Technical Department is always willing to help you solve them.

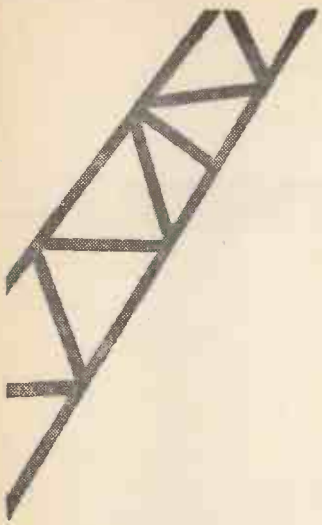
Vacuum Ovens with temperatures of up to 600°C are also manufactured by us on similar lines but with Sectional Heating and Water-Cooled Ends.

VACWELL ENG. CO. LTD.

VACWELL ENGINEERING CO. LTD.

WILLOW LANE, MITCHAM, SURREY

Phone : MITcham 8211 (3 lines)



Once again HALTRON is in the forefront with additional latest types making their stock still more comprehensive. Our prices are most competitive and can be had on application.

Your specific enquiries for special types to CV. JAN and MIL specifications are invited.

Our organisation is Air Registration Board approved.

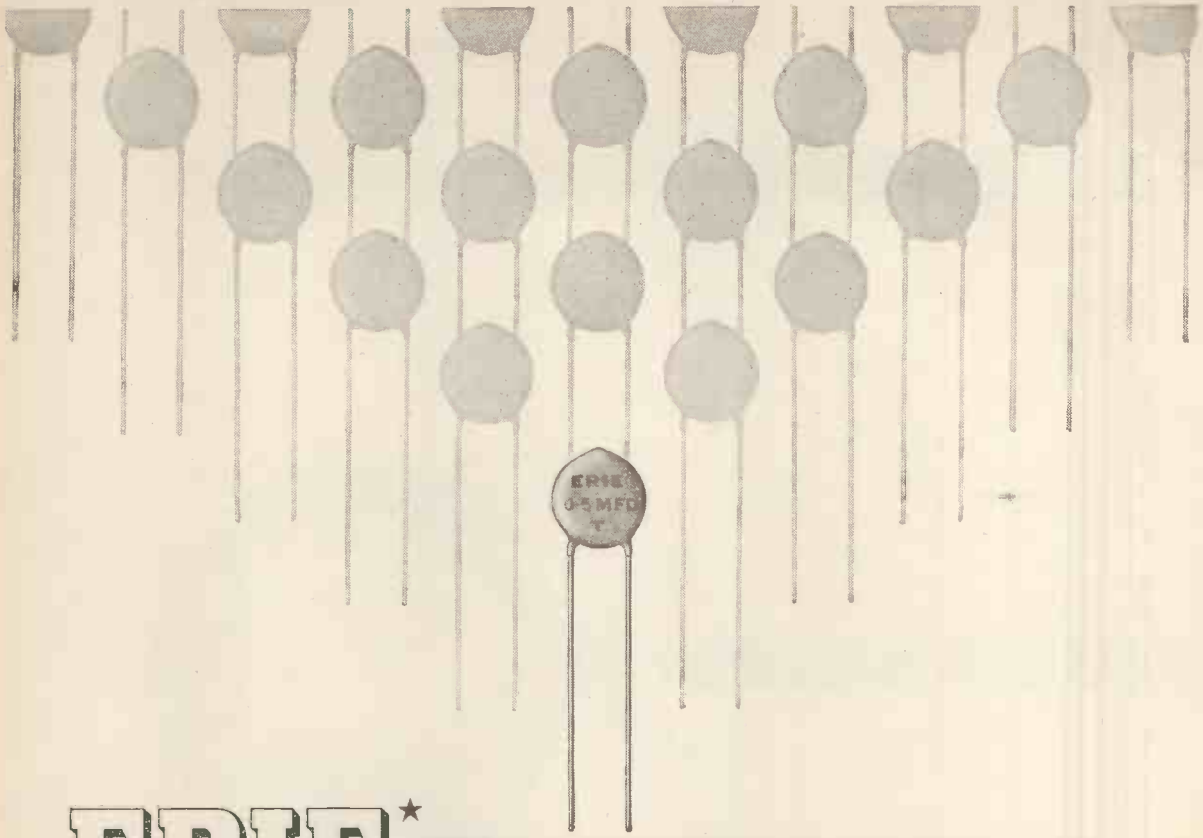
HALTRON

HALL ELECTRIC LTD

HALTRON HOUSE, ANGLERS LANE, LONDON N.W.5.

Tel.: Gulliver 8531 (10 lines) Telex 2-2573 Cables: "Hallectric London"

HALTRON



ERIE★ Transcaps

for all Transistor Circuits

SPECIFICATION

Diameter : 0.594 inches maximum

Thickness : 0.156 inches maximum

Capacitance : 0.5 mfd

Tolerance : −20% +50%

Working voltage : 3 volts d.c.

Power factor : Not greater than 5%, when measured at 1 kc/s, and less than 0.5 volts

Leakage resistance : Not less than 100,000 ohms, when measured at 3 volts

In line with the Erie policy of anticipating the component requirements of the future, the Erie Transcap capacitor is now added to our ever-increasing range of components for use with transistors.

Designed specifically as a small, reliable, high capacitance, low voltage, coupling, and by-pass capacitor, the Erie developed Transcap is manufactured entirely at our Great Yarmouth factory.

Style T, shown here in its actual physical size, is but a forerunner of the wide range, in differing values and voltages, which will ultimately emerge.

ERIE★ RESISTOR LIMITED

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Telephone: REGent 6432

FACTORIES

Great Yarmouth and Tunbridge Wells, England: Trenton, Ont., Canada: Erie, Pa., Holly Springs, Miss., and Hawthorne, Cal., U.S.A.

★*Registered Trade Mark*

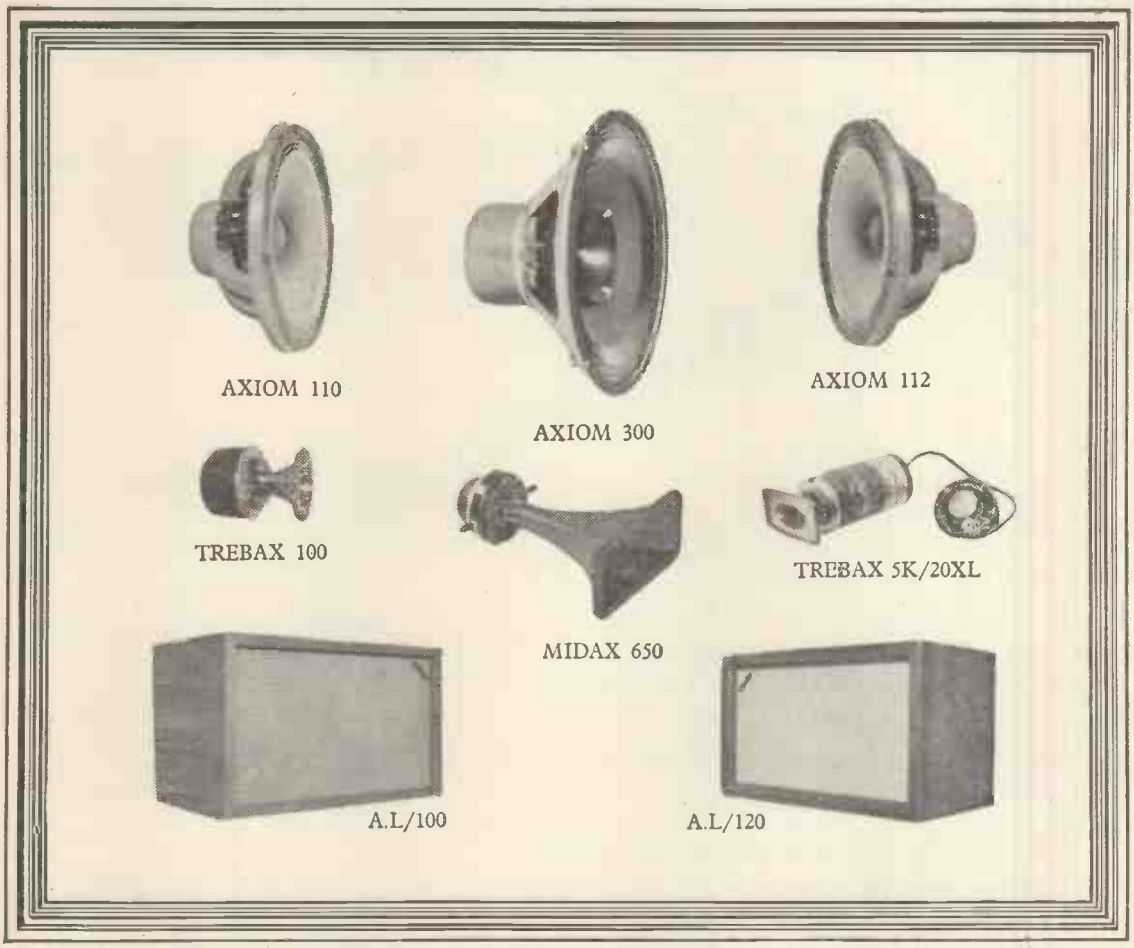
X TYPE	DESCRIPTION	MAX. VSWR.	
PP 4020 X	Straight Waveguide Section	—	Length 10, 20, and 40 cm
PP 4025 X	E-plane Bend	1.07	Radius of curvature 29 mm
PP 4030 X	H-plane Bend	1.07	Radius of curvature 29 mm
PP 4035 X	Twist	1.10	Length 187 mm
PP 4040 X	Shunt Tee	—	Length 80 mm
PP 4045 X	Series Tee	—	Length 80 mm
PP 4050 X	Hybrid Tee	—	Decoupling > 40dB
PP 4070 X	Waveguide/Coaxial Adapter	1.50	50 Ω N-connector
PP 4080 X	Horn	1.25	Directivity: E-plane 20°, H-plane 25°
PP 4090 X	Multi-hole Directional Coupler	1.05	Directivity: >40dB, coupling factor 10dB or 20dB (± 0.2dB)
PP 4095 X	Cross-guide Directional Coupler	—	Directivity: 20dB, coupling factor 26dB (± 0.5dB)
PP 4110 X	Fixed Attenuator	1.10	Attenuation 6, 10 or 20dB (± 0.2dB), max. peak power 1 kW
PP 4130 X	Variable Flap Attenuator	1.15	Max. attenuation > 20dB
PP 4150 X	Variable Rotary Attenuator	1.15	Max. mean power 1 W, max. attenuation 50dB, accuracy ± 2 %
PP 4170 X	Low-power Matched Load	1.05	Max. mean power 2 W
PP 4200 X	Klystron Mount	—	When using klystron 2K25 the output power is > 20 mW
PP 4220 X	Adjustable X-tal Mount	1.10	Sensitivity: 1 mV D.C. for 0.1 μW, 50 Ω N-connector
PP 4225 X	Broadband X-tal Mount	1.50	Sensitivity: 1 mV D.C. for 10 μW, 50 Ω BNC-connector
PP 4245 X	Tunable Thermistor Mount	1.10	Freq. range 8.2-11 kMc/s, 50 Ω BNC-connector
PP 4260 X	Calibrated Short Circuit	>100	Accuracy of the displacement 0.02 mm
PP 4280 X	Sliding Screw Tuner	from 20 to >1.02	Insertion loss for a VSWR of 20 is > 2dB
PP 4290 X	Direct Reading Wavemeter	—	Freq. range 8.5-9.8 kMc/s, absolute accuracy ± 2 Mc/s, loaded Q 10,000
PP 4300 X	Broadband Wavemeter	1.10	Relative accuracy 3.10^{-4}, loaded Q > 3,000
PP 4360 X	Measuring Cavity	—	Freq. range 8.65-8.95 kMc/s, loaded Q > 3,000, magnetic field for electron resonance 3,300 gauss
PP 4380 X	Standing Wave Detector	1.05	Accuracy of the probe displacement 0.01 mm, 50 Ω BNC-connector
PP 4385 X	High Precision Standing Wave Detector	—	Measurable VSWR between 1.005-2.000, accuracy probe displacement 2 μ, probe penetration 0-3 mm
PP 4421 X	Ferrite Isolator	1.15	Freq. range 8.5-9.6 kMc/s, forward att. < 0.8dB, reverse att. > 13dB, max. peak power 50 kW
PP 4422 X	Ferrite Isolator	1.20	Freq. range 8.5-9.6 kMc/s, forward att. < 0.5dB, reverse att. > 20dB, max. mean power 1 W
PP 4500 X	3 cm Noise Generator	>1.20	Noise factor 18.7dB (K50A), attenuation 0-13dB

Additional Instruments: **D.C. Microvoltmeter, type GM 6020 - Klystron Supply, type GM 4561 - Bolometer Bridge, type GM 4460**

Q TYPE	DESCRIPTION	MAX. VSWR.	
PP 4020 Q	Straight Waveguide Section	—	Length 5, 10 or 20 cm
PP 4025 Q	E-plane Bend	1.07	Radius of curvature 35 mm
PP 4030 Q	H-plane Bend	1.07	Radius of curvature 37 mm
PP 4035 Q	Twist	1.07	Length 50 mm
PP 4050 Q	Hybrid Tee	—	Decoupling >35dB
PP 4080 Q	Horn	1.15	Directivity: E-plane 15°, H-plane 16°
PP 4130 Q	Variable Flap Attenuator	1.15	Max. attenuation > 20dB max. mean power 200 mW
PP 4150 Q	Variable Rotary Attenuator	1.15	Max. attenuation 50dB, accuracy ± 3 %
PP 4170 Q	Low-power Matched Load	1.05	Max. mean power 1 W
PP 4200 Q	Klystron Mount	—	When using klystron 55,335 the output power is 100 mW
PP 4222 Q	Adjustable X-tal Mount	1.25	50 Ω BNC-connector
PP 4260 Q	Calibrated Short Circuit	50	Accuracy of the displacement 0.02 mm
PP 4270 Q	Sliding Screw Tuner	from 10 to 1.03	Insertion loss for a VSWR of 10 is > 2dB
PP 4300 Q	Broadband Wavemeter	1.20	Relative accuracy 5.10^{-4} loaded Q > 3000
PP 4382 Q	Standing Wave Detector	1.03	Accuracy of the displacement 0.01 mm max. probe penetration 1 mm, 50 Ω BNC-connector
PP 4420 Q	Ferrite Isolator	1.15	Freq. range 33-36 kMc/s, forward att. < 1dB reverse att. 13-26dB, max. mean power 200 mW

Additional Instruments: **Klystron Supply, type 4485 - D.C. Microvoltmeter, type GM 6020**

From the Greatest Range with the Greatest Name . . .



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Established over 30 years ago, Goodmans Industries are now the largest manufacturers of High Fidelity Loudspeakers in Europe. A Tradition of Excellence has been maintained throughout this period, achieving World-wide recognition.

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B

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The Bang and Olufsen STEREODYNE Pick-up is a unique 4 pole 4 coil moving iron system. FUNDAMENTALLY correct in principle and geometry for stereo disc recordings and provides equal compliance in all directions with high channel separation through the entire frequency range.

★ **PRECISION ENGINEERED LIGHT ALLOY ARM**
★ **LOW FRICTION—LOW MASS**
★ **ADJUSTABLE TRACKING PRESSURE 1-4 GRAMS**
★ **PLUG-IN CARTRIDGE—EASY CHANGE, DIAMOND STYLUS**
★ **HIGH OUTPUT—LOW IMPEDANCE, HUM BALANCED SYSTEM**

Stereodyne arm complete with cartridge	**£17.17.0 inc. P.T.**
Cartridge complete with stylus	**£7. 7.0 inc. P.T.**
Replacement Diamond stylus	**£2.14.0 inc. P.T.**

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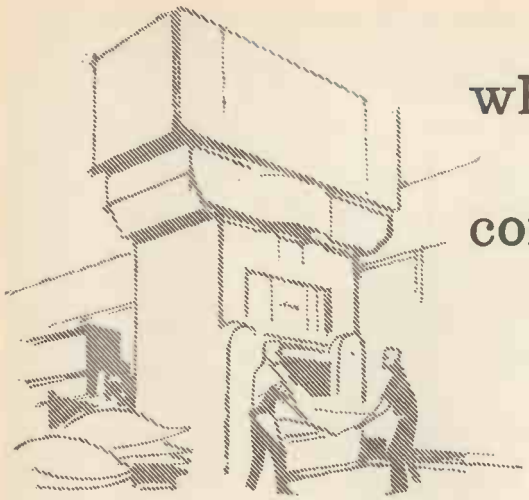
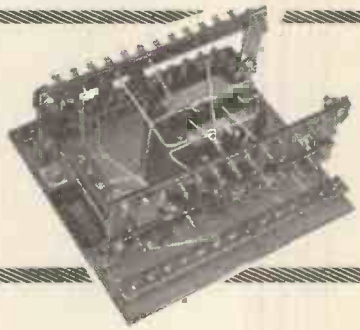


wherever rugged contactless control equipment is vital you'll need Sanders

STATIC SWITCHING SYSTEMS

The **Proximity Switch** will provide a signal to operate a Basic Logic Unit, whenever a mass of ferrous material comes within 5mm of the operating face. Having no moving parts, it is an encapsulated wound component suitable for use in conditions of vibration, shock, dust, damp—in fact, in any environment where the epoxy potting compound and the cable gland will not be damaged.

The **Contactless Changeover Switch**, a form of differential transformer, will provide signals to operate Basic Logic Units, changing over when the armature is rocked by about 1.5 degrees i.e. 1mm movement at one end. Apart from the solid steel armature which pivots on a stainless steel pin in a bronze bush, there are no moving parts; the body of the device being similar to that of the proximity switch.



The **Basic Logic Unit** provides the normal logic functions i.e. OR, AND, AND / NOT, LATCH etc. The standard inputs signal is 1.5 Volts at 68 ohm, although pre-amplifiers can be provided if required. An output of 900mW into 47 ohms is normal for the basic logic unit, sufficient to drive any Sanders transductor from 1 Watt output to 10kW output.
The latching units have a "MEMORY" facility enabling them to remain latched during total power failure.

This Static Switching System provides control equipment without the use of electrical contacts which may corrode, weld or wear out and with the minimum moving parts required to provide the initial information to the system. The only electrical components used in the entire system are encapsulated transductors, wirewound resistors, transformers and silicon rectifiers—components used well within the manufacturers' limits to ensure reliability.
The information fed to the basic logic units can be derived from photo-electric cells, tacho-generators and any device that will provide a few milliamps into a 100 ohm winding.

This is one of a series of new instruments and components by

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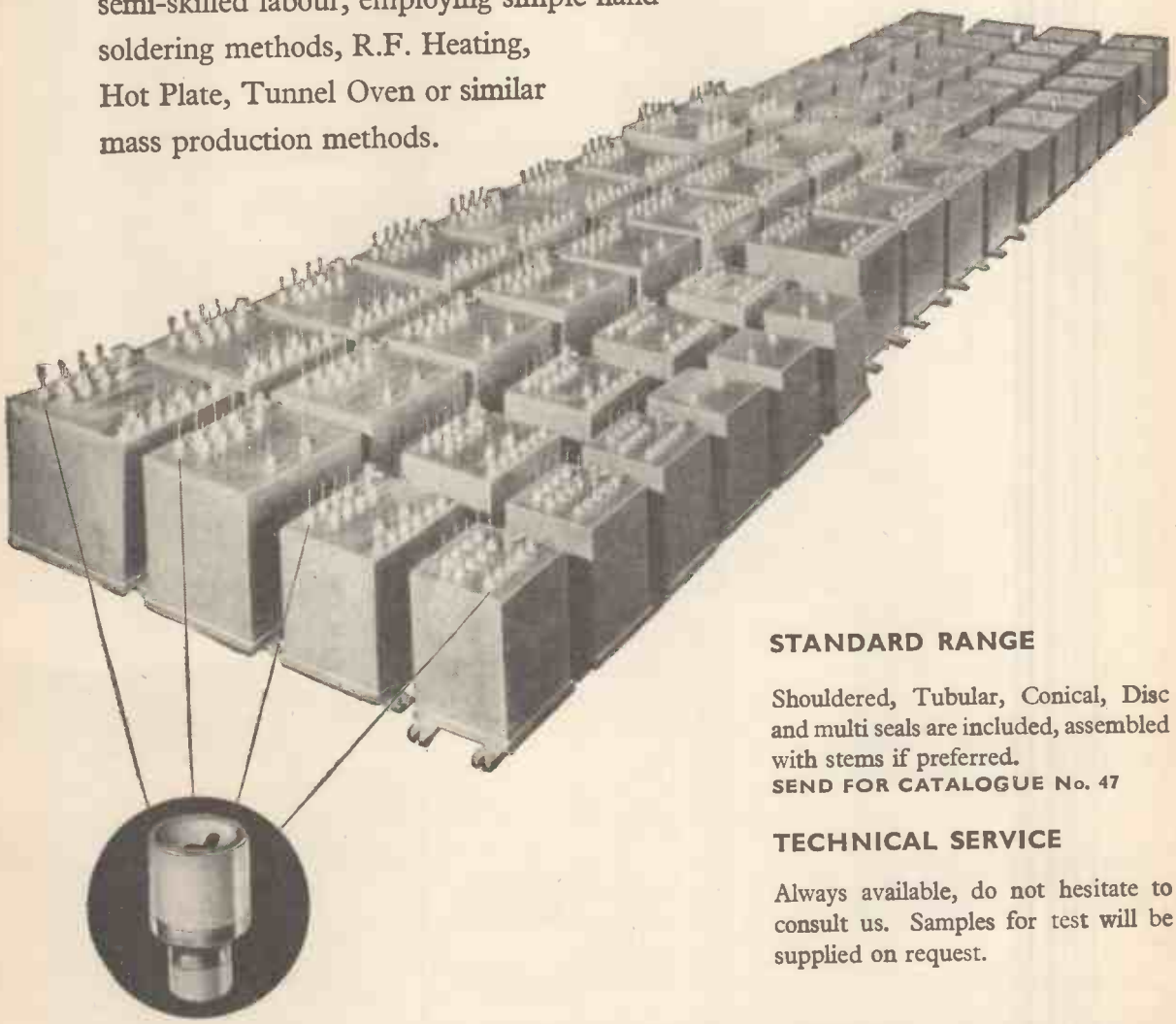

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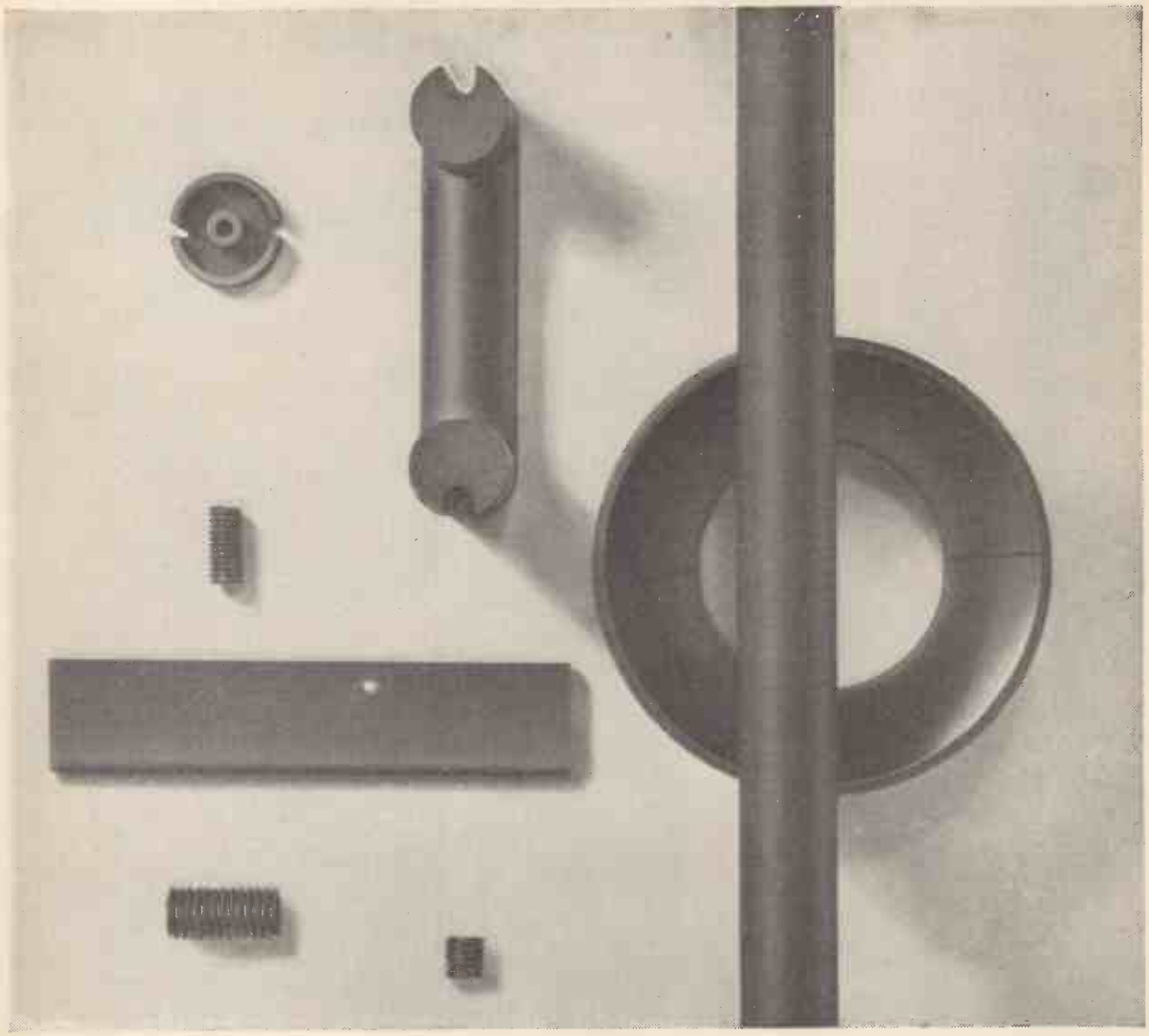

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TC20a

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These two instrument tubes are being produced by **ETEL** to fulfil the requirements of a variety of applications where a 5-inch tube is needed. Both the 5BUP31 and 5BVP31A are high quality p.d.a. tubes with flat screens and side plate connections. Their range of operating voltages is wide and is an important feature of their versatility. The screen of the 5BVP31A is aluminized, and the higher operating voltages allowed with this tube suit it for recording faster phenomena. Full data is available upon request to the address below.

Abridged Data

Heater
Vh = 6.3V Ih = 0.55A

Capacitances
Cx'–x" . . . . . 1.6pF.
Cy'–y" . . . . . 1.5pF.
One X plate to all other electrodes less other X plate—3.0pF.
One Y plate to all other electrodes less other Y plate—2.7pF.

Typical Operation

	5BUP31	5BVP31A
Va1 . . .	2.0kV	1.5kV
Va2 . . . (for focus)	500V approx.	1.0kV approx.
Va3 . . .	2.0kV	4.0kV
Va4 . . .	4.0kV	8.0kV
Vg . . .	-28 to -62V	-43 to -92V
Sx . . .	29V/cm	57V/cm
Sy . . .	17.5V/cm	35V/cm

(The green medium persistence phosphor used by E.T.L. has now been designated P31. It is exactly the same as the E.T.L. phosphor previously called P1.)

ETEL

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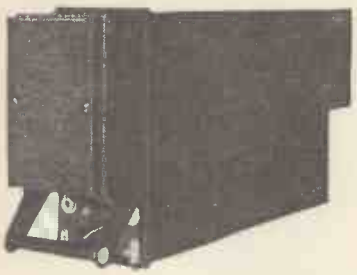
ETL22a



AD 160
V.H.F. communication system.
V.H.F. Transmitter type 6400
(short ½ ATR. 14 lbs.).

AD 160
V.H.F. communication system.
V.H.F. Receiver type 6401
(short ½ ATR. 8 lbs.).

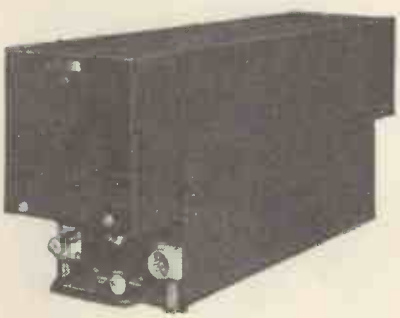
BILITY

AD 260
V.H.F. Navigation system.
V.H.F. Receiver type 6401
(short ½ ART. 8 lbs.).

AD 260
V.H.F. Navigation system.
Navigation unit type 6402
(short ½ ATR. 9 lbs.).

AD 260
V.H.F. Navigation system.
Glide Slope Receiver type
6404 (short ½ ATR. 6 lbs.).

AD 260
V.H.F. Navigation system.
Marker Receiver type 6403
(dwarf short ½ ATR. 3 lbs.)



AD 360
Automatic Direction Finder
ADF Receiver type 6407
(short ½ ATR. 18½ lbs.).

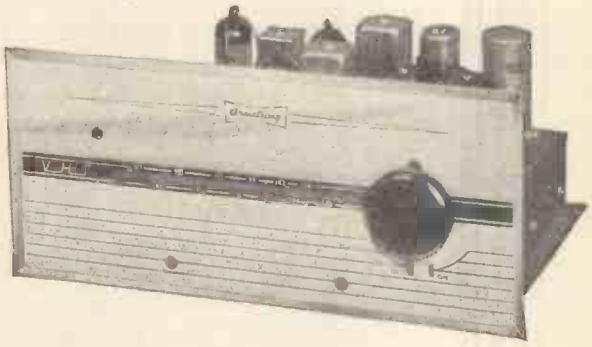
AD 308
Radio Teleprinter Receiver.
Receiver type 4486
(short ½ ATR. 9 lbs.).

★ Armstrong Quality Tuners

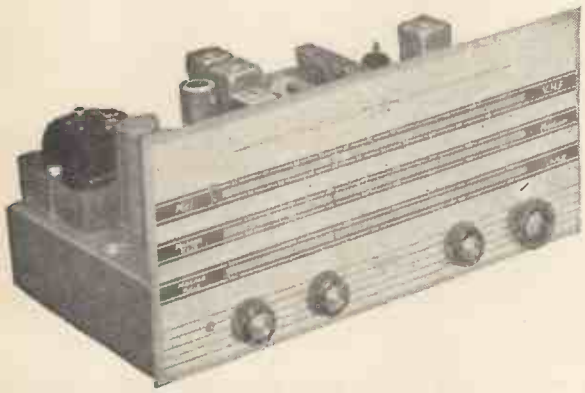
T4 FM TUNER 19gns

A high fidelity VHF tuner of attractive appearance and superb design. Incorporating features normally found only in the most expensive tuners it represents outstanding value at its price. It is completely stable with no trace of drift and A.F.C. provides broad easy tuning. A polished wood cabinet (£2/16/-) is available for those who require a separately mounted tuner.

- *Self-powered.*
- *Full VHF band (87-108 Mc/s.).*
- *Automatic frequency control.*
- *Cathode follower output.*
- *Variable output 0–500mV.*
- *Multiplex output for stereo radio adapter.*
- *Separate 75 ohm and 300 ohm aerial inputs.*



are designed to match any



ST3 Mk2 AM/FM TUNER . . 27gns

This new tuner is the successor to the well-tried and successful ST3. Improvements in design and a considerable reduction in size make the new tuner even more attractive than its predecessor. It includes all the features of the T4 tuner and the A.M. section covers the long and medium wavebands. The ferrite aerial and unique 2nd I.F. stage ensure good continental reception and there is a miniature bright-line indicator for easy tuning.

- *Self-powered.*
- *Automatic frequency control.*
- *Cathode follower stage with variable output.*
- *Multiplex output for stereo radio adapter.*
- *Ferrite rod aerial on AM and separate aerial inputs on FM.*

amplifier or tape recorder

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★ *The name ARMSTRONG is our registered trade mark*

Although Armstrong tuners are suitable for use with any amplifier, we recommend, for the enthusiast who wants the best, the Armstrong PCU27 Stereo Pre-Amplifier (£26.10.0d.) together with A10.Mk2 Power Amplifier (£21.10.0d.) Use one A10.Mk2 for mono or two for stereo.

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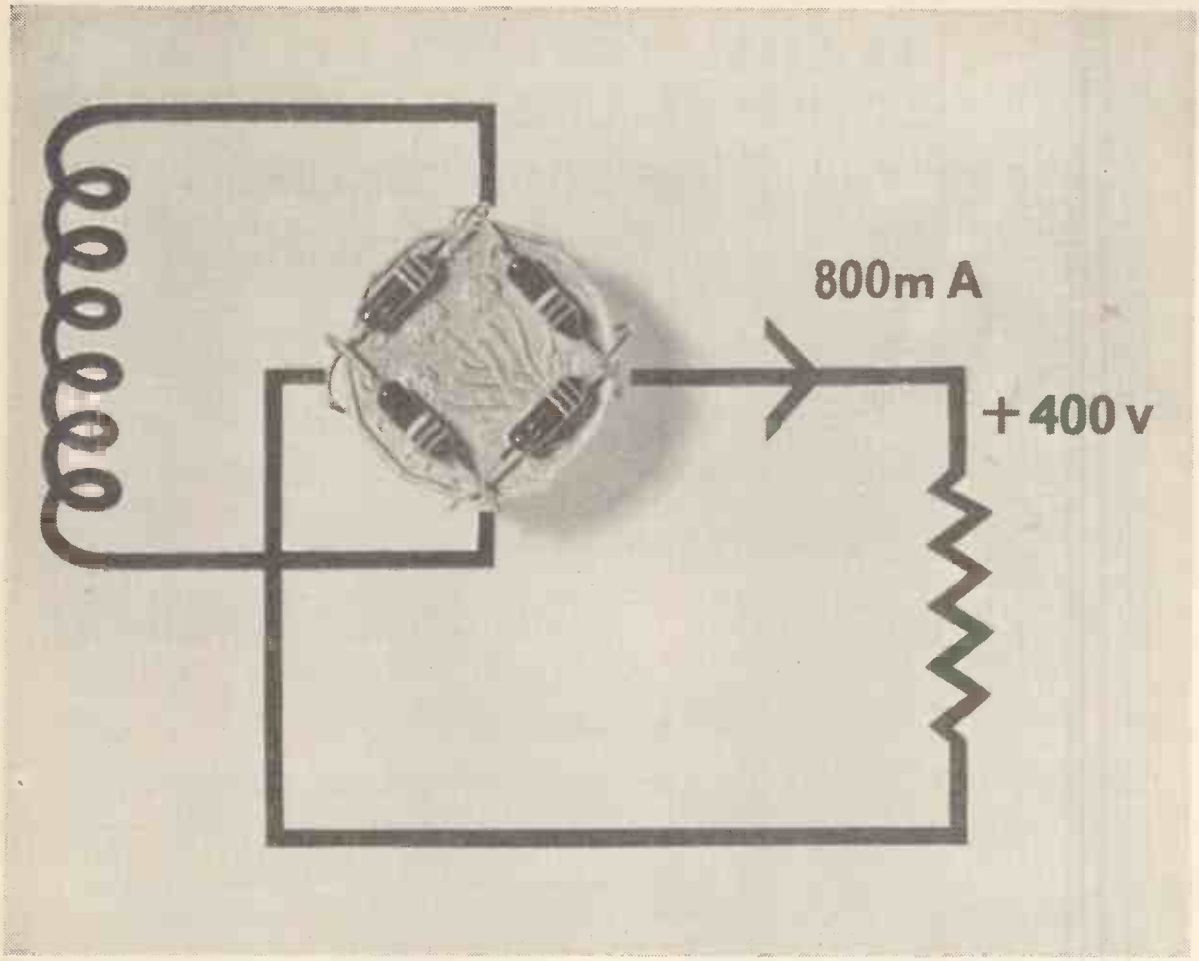

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	P out† (W)	Distortion† (%)	V supply (V)	DIMENSIONS Seated height (mm)	DIMENSIONS Max diameter (mm)
KT 55	25	1.5	*	128	53
KT 66	50	3	525	120	53
KT 77	70	1	600	98	33
KT 88	100	1.5	500	110	53

† Class AB_1, ultra-linear connection
* 190—260 V, AC or DC mains

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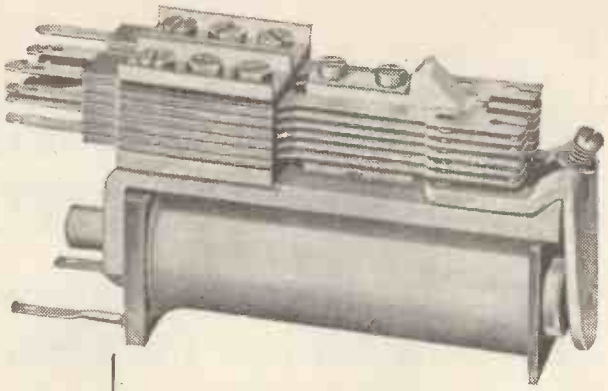

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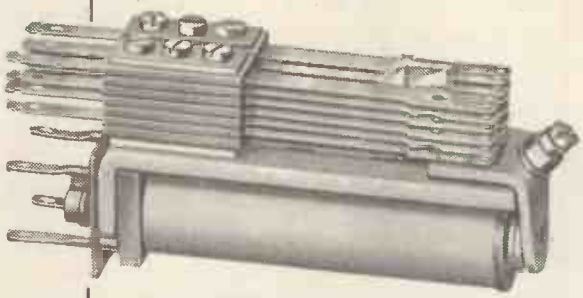
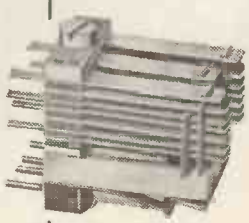
Type 3000, available with a wide range of contact combinations, coil resistances and slugs.
Tropical finish type approved to RCS 161.
Standard finish for telecommunications applications in temperate climates.



Type 600, available with a wide range of contact combinations and coil resistances.
Tropical finish type approved to RCS 161.
Standard finish for telecommunications applications in temperate climates.

Remanent (magnetic latching) versions of type 3000 and type 600 are also available.



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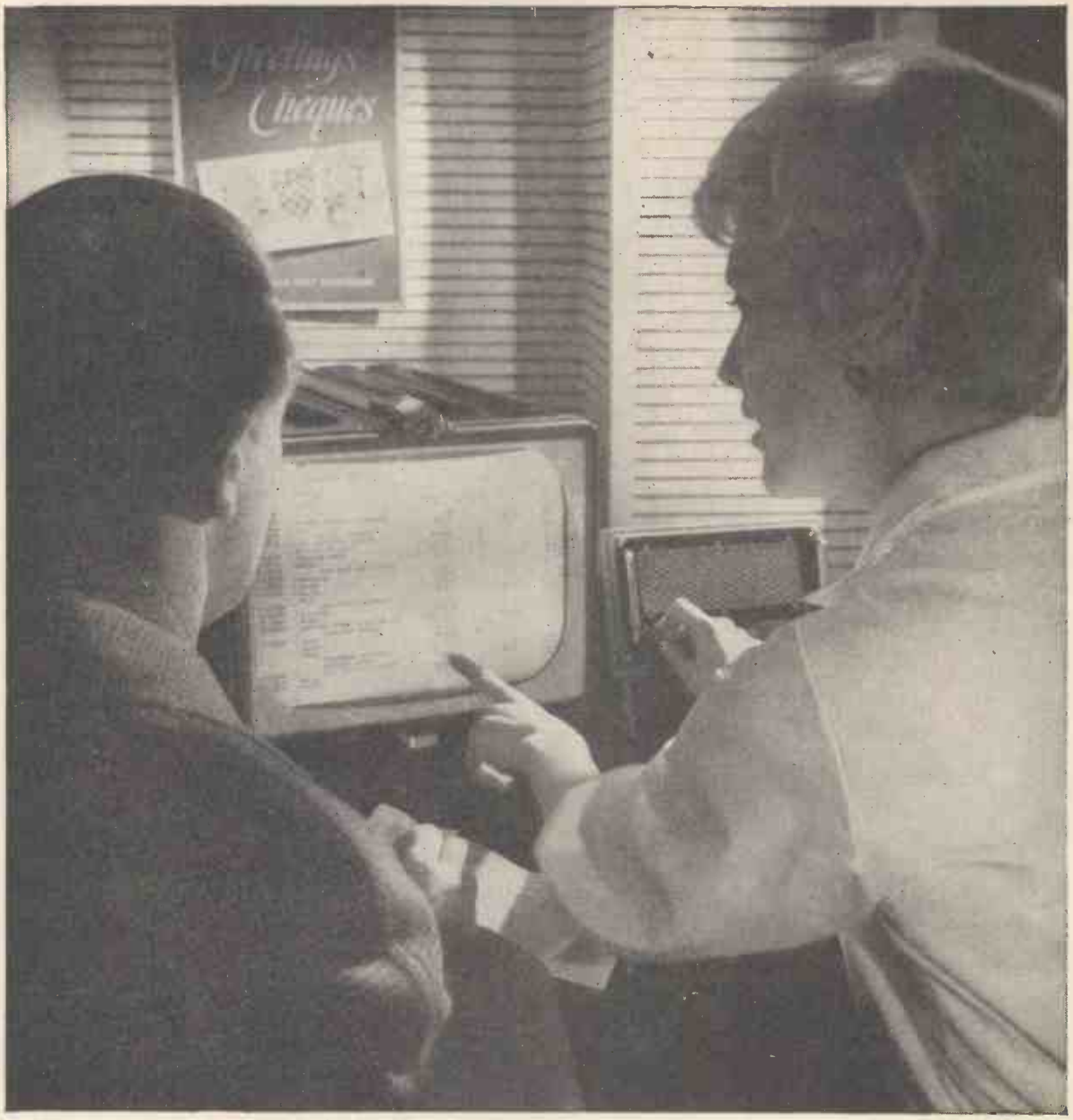
REPRESENTATION IN 68 COUNTRIES

TC186



Westminster Bank uses Pye Television

The Pye Industrial TV Division, a member of the Pye Instrument Group, has supplied all the television equipment to the Westminster Bank for the first inter-branch TV network. The new system which makes centralised book-keeping possible has been brought about by the closest co-operation with the GPO who have supplied Post Office lines to carry the signals. The illustration shows a customer checking his banking account.

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Wireless World

ELECTRONICS, RADIO, TELEVISION

DECEMBER 1960

VOLUME 66 No 12.

PRICE: TWO SHILLINGS

FIFTIETH YEAR OF PUBLICATION

Offices: Dorset House, Stamford Street, London, S.E.1

Please address to Editor, Advertisement Manager, or Publisher, as appropriate

PUBLISHED MONTHLY (4th Monday of preceding month) by ILIFFE & SONS, LTD., Dorset House, Stamford Street, London, S.E.1. *Telephone:* Waterloo 3333 (65 lines). *Telegrams:* " Ethaworld, Sedist, London." *Annual Subscriptions. Home and Overseas,* £1 15s. 0d. *Canada and U.S.A.,* $5.00. Second-class mail privileges authorised at New York, N.Y. BRANCH OFFICES: *BIRMINGHAM:* King Edward House, New Street, 2. *Telephone:* Midland 7191. *COVENTRY:* 8-10, Corporation Street. *Telephone:* Coventry 25210. *GLASGOW:* 62, Buchanan Street, C.1. *Telephone:* Central 1265-6. *MANCHESTER:* 260, Deansgate, 3. *Telephone:* Blackfriars 4412. NEW YORK OFFICE: *U.S.A.:* 111, Broadway, 6. *Telephone:* Digby 9-1197.

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"BELLING-LEE" NOTES

No. 23 of a Series

Fusing, part 7

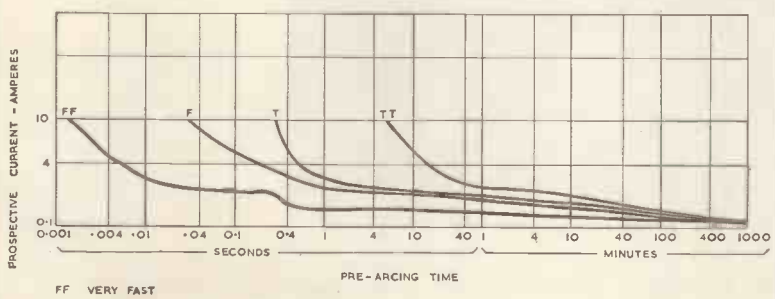
A convenient way of expressing the degree of protection afforded by a fuse is by stating the "Fusing Factor"; this is the ratio of the minimum value of current which will blow it to the current rating. Thus a 2 amp. fuse having a fusing factor of 2:1 will not operate normally at any current below 4 amp., although it should be appreciated that if it is subjected to currents between 2 and 4 amp. there will be an excessive temperature rise (possibly beyond what is permitted) and, depending on the material of which its element is made, embrittlement may result, followed ultimately by failure as we have seen earlier.

Now fuselinks having different types of construction and performance can have similar fusing factors, and so, useful as this characteristic is, it gives no indication of the mode of operation, which is a function of current and time. The readiest way of expressing this is pictorially, in the form of graph. In its conventional form, this is a curve drawn through a minimum of six points plotted on Cartesian co-ordinates whose axes are prospective current, and pre-arcing time, shown on logarithmic scales. The current source which is used to obtain the results so plotted is usually D.C., since an alternating supply would give misleading results at very short pre-arcing times because they would depend on the instantaneous value of the current at the time of applying the overload; at fairly long pre-arcing times, of course an alternating current (r.m.s. value) would give the same result as D.C.

A typical set of characteristic curves is shown for four different types of fuses having the same rating and fusing factor. The usefulness of these curves can be considerably extended by plotting them as envelopes containing the spread of results obtained in practice due to random variations between different specimens, as we indicated in part 3 of this series. The upper boundary then provides information on the absolute protection given by that particular type of fuse, while the lower boundary defines the maximum *isolated* surge that the fuse will withstand.

Curves of this type are indispensable when considering problems of discrimination. In any system which includes two or more circuit protection devices arranged in series, it is obviously undesirable that a fault should operate more than one of them. For instance, in an ordinary domestic electrical installation there are a number of individually fused outlets (sub-circuits) fed through a main circuit fuse, and it would be most inconvenient if a fault arising in one of the sub-circuits blew the main fuse thus putting all the other sub-circuits out of action; in some situations it could even be dangerous. The characteristics of the main fuse must therefore be such that it is able to discriminate between a main circuit fault and an overload in a sub-circuit and the simplest way of ensuring this is by seeing that its performance curve nowhere intercepts those of the sub-circuit fuses.

COMPARISON OF FUSE CHARACTERISTICS



FF VERY FAST
F FAST
T TIME LAG
TT EXTRA TIME LAG

E.M.I. COLOUR T.V.

Colour TV makes its first appearance on any European race-course, and 3,000 people in special marquees at Redcar see two days' racing in brilliant, accurate colour . . .

An operation takes place in Hammersmith Hospital, and a large audience many miles away sees every detail faithfully reproduced in colour . . .

Just two examples from the ever-growing list of successful uses of E.M.I.'s Colour Camera Channel Type 204. Smaller, easier to use and less expensive than existing equipment, E.M.I.'s Colour Channel uses a novel optical system and three vidicon tubes to provide extremely faithful rendering of colour, even under difficult lighting conditions. E.M.I.—holders of original patents for the world's first high-definition TV system—has already demonstrated the suitability of this new Channel for many applications in industry, medicine and science.

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A demonstration will gladly be arranged for you. Write or telephone:

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BROADCAST EQUIPMENT DIVISION, HAYES, MIDDLESEX

TELEPHONE: SOUTHALL 2468, EXT. 2011

EE133

Aspects of design

This is No. 29 in the series of articles dealing with advanced problems in circuit design published by The Ediswan Mazda Applications Laboratory. No. 30 will appear next month. We shall be pleased to answer queries arising from this or other articles. Reprints of the first twenty-four articles, in booklet form, are available on request.

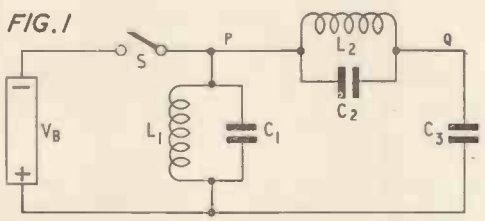
29 TUNING OF TELEVISION LINE OUTPUT TRANSFORMERS

The operation of line deflection output stages of television receivers was dealt with in " Aspects of Design " numbers 8 and 26. It was pointed out in " Aspects of Design " number 26 that an output stage can be operated more efficiently if the ratio of the number of turns on the efficiency diode winding of the transformer to the number of turns on the pentode winding is kept as high as possible. This results in a high value of boosted HT voltage which, although assisting in producing good efficiency, subjects the pentode and efficiency diode to higher peak voltages during the line flyback interval. The Maximum Peak Voltage ratings of diode and pentode often set a limit to which this course can be pursued. By suitable proportioning of transformer leakage inductance and self-capacitance a condition of tuning can be achieved which allows these peak voltages to be considerably reduced. This process is often termed 3rd Harmonic Tuning.

This technique can best be understood by considering the equivalent circuit of a line output stage.

Fig. 1 shows the equivalent circuit of a typical line output stage in which a winding or " overwind " is included to step up the peak voltages during flyback for the purpose of generating the cathode ray tube extra high voltage supply. The various elements of the circuit are shown as referred to the primary of the transformer. L_1 represents the parallel combination of deflector coil load inductance and primary inductance. L_2 represents the leakage inductance between pentode anode connection and EHT rectifier connection

FIG. 1



C_2 and C_3 are the small capacitances associated with this inductance. C_1 which is large provides most of the tuning of the inductance load. The switch represents the combination of pentode and efficiency diode. At the end of the deflection stroke L_1 carries a high current which is rising linearly at a rate slow compared with the natural resonance periods of the circuit. The switch is opened and the circuit commences a free oscillation. At the end of the flyback interval the current in L_1 has reversed and has reached a maximum in the opposite direction. Very shortly after this time there comes a moment when the rate of change of current in L_1 and therefore the voltage across C_1 have the same value as they had during the previous deflection stroke. The switch is now closed once more and this current is constrained to collapse linearly to zero at a rate $L_1 \frac{di_1}{dt} = V_B$. This linearly decaying current flows into the battery returning energy in doing so.

If there is current in L_2 or charge on C_2 at the moment of closing the switch the circuit L_2 C_2 C_3 will continue to oscillate during the next stroke. In any practical circuit the switch comprising the pentode and efficiency diode has finite resistance which serves to couple oscillations of L_2 C_2 C_3 into the load inductance L_1 where they produce velocity modulation of the trace. In addition the energy of this circuit L_2 C_2 C_3 will be dissipated in its losses and will not be available for recovery by the energy recovery process. The aim of third harmonic tuning is that at the end of the flyback interval there shall be no current in L_2 and no charge on C_2. This implies that at the end of the flyback interval the current in L_2 is zero and the rate of change of current is also zero. During the free flyback oscillation L_2 can be supposed to carry components of current at the two natural frequencies of the circuit. These frequencies are f_1, a low frequency mainly governed by L_1 C_1 and f_2 a higher frequency governed mainly by L_2 in parallel with C_2 and C_3, C_1 appearing as a very low impedance.

Fig. 2(a) shows a plot against time of these two components of current in L_2 during the flyback interval with the circuit constants critically adjusted for the " 3rd Harmonic " tuning condition. This occurs when f_2 is slightly less than 3 f_1. The total current in L_2 is the sum of these components and this is shown in Fig. 2(b). It is seen that this condition achieves the requirement of current in L_2 and rate of change of current being simultaneously zero at the beginning and end of the flyback interval. The voltage waveform across L_2 is shown by the dotted curve in Fig. 2(b) (voltage of point P with respect to point Q). The effect of this is to depress the voltage peak at P, the pentode anode, and increase the voltage peak at Q, the EHT rectifier point.

These waveforms are shown in Fig. 3. The waveform at Q, of course, is of greater amplitude than that at P by the step up action of the transformer ratio which, for simplicity, has been omitted from the equivalent circuit.

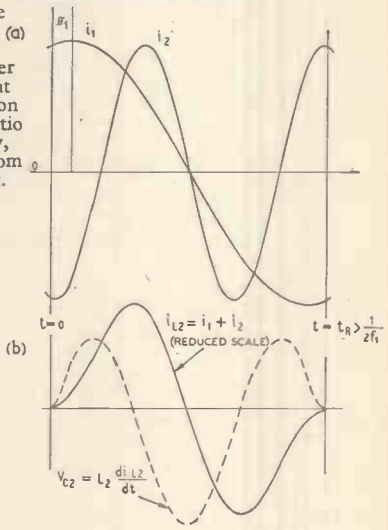
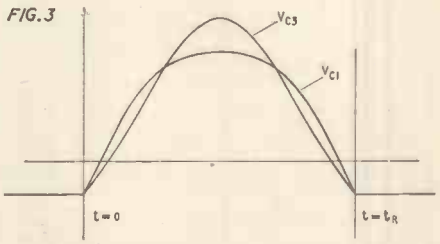


FIG. 2 i_1 IS EXAGGERATED GIVING $f_2 = 2.63 f_1$

FIG. 3



In practice L_2 C_2 and C_3 are governed by the transformer winding configuration and only C_1 is under control by adding capacity across the transformer primary. The procedure in design is to adjust C_1 for the tuning condition by observing cancellation of ringing on say the pentode anode waveform and then measuring flyback time. If, for instance, flyback time is too short then the winding must be redesigned for greater leakage inductance L_2 or greater self capacitance of the EHT overwind to reduce f_2 and the transformer re-tuned for the " 3rd Harmonic" condition.

The Ediswan Mazda 30P4 and 30P19 are processed to have good high voltage performance to give the engineer scope for achieving very efficient designs using this procedure.

Associated Electrical Industries Ltd
Radio and Electronic Components Division
Technical Service Department
155 Charing Cross Road, London, W.C.2
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NEW HIGH POWER TRIODE BEAM TETRODE

EDISWAN MAZDA 30PL14

The 30PL14 Triode Beam Tetrode is intended principally for use in frame deflection circuits of television receivers using 110° and 114° cathode ray tubes. The tetrode section has been designed to operate with a low ratio of screen to anode current whilst the available peak anode current and anode dissipation are higher than in the 30PL13. The higher available peak anode current will, in many cases permit economies in output transformer design. The triode section is a general purpose triode with identical characteristics to the 6/30L2, and that of the 30PL13, for use as a deflection drive voltage oscillator, frame sync. pulse separator etc.

Heater Current (amps)	I_h	0.3
Heater Voltage (volts)	V_h	16

TENTATIVE RATINGS AND DATA

Maximum Design Centre Ratings

		Triode	Tetrode
Anode Dissipation (watts)	$p_{a(max)}$	1	8
Screen Dissipation (watts)	$p_{g2(max)}$	—	2
Peak Anode Voltage (Pulse positive) (kV)		—	2*
Peak Anode Voltage (Pulse negative) (kV)		—	0.5*
Anode Voltage (volts)	$V_{a(max)}$	250	250
Screen Voltage (volts)	$V_{g2(max)}$	—	250
Heater to Cathode Voltage (volts rms)	$V_{h-k(max)rms}$	150†	150†
Mean Cathode Current (mA)	$I_{k(max)}$	—	75
Resistance Grid 1 to Cathode			
Self Bias (MΩ)		—	2
Fixed Bias (MΩ)		—	1

*Maximum pulse duration 5% of one cycle with a maximum of 1 msec.

†Measured with respect to the higher potential heater pin.

TRIODE CHARACTERISTICS

Anode Voltage (volts)	V_a	200
Anode Current (mA)	I_a	10
Grid Voltage (volts)	V_{g1}	−7.7
Mutual Conductance (mA/V)	g_m	3.4
Amplification Factor	μ	18

TETRODE OPERATION IN FRAME TIME BASE

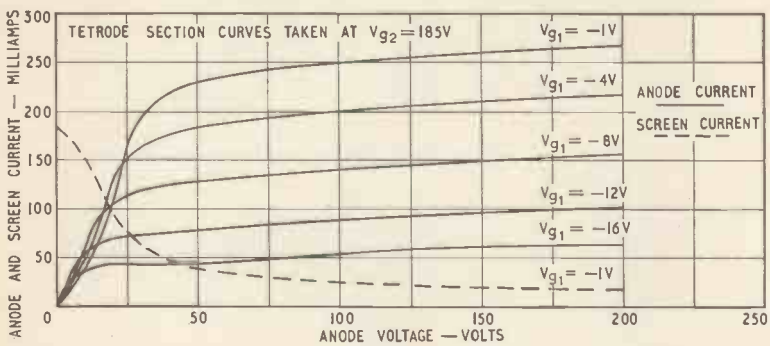
Allowance must be made in circuit design, not only for component variation, but for valve spread and deterioration during life. Values of total tetrode peak anode current, for an average valve when new and at the assumed end of life point for any valve, are as follows:—

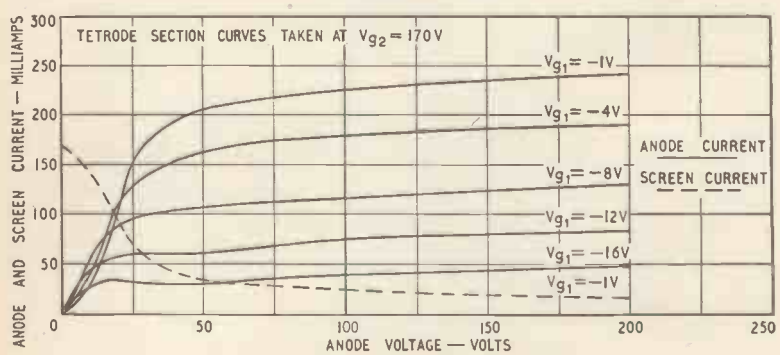
	V_a (V)	V_{g2} (V)	V_{g1} (V)	I_a (mA)
Average New Valve	55	170	−1	210
Assumed End of Life Condition	50	170	−1	135
Average New Valve	55	185	−1	235
Assumed End of Life Condition	50	185	−1	151

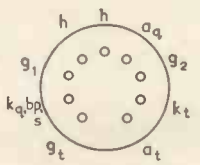
Mounting Position: Unrestricted

Base: B9A (Noval)

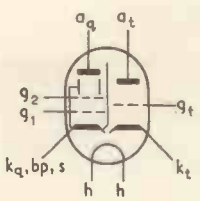
Tentative Characteristic Curves of Ediswan Mazda Transistors Type 30PL14







VIEW OF FREE END



Maximum Dimensions (mm)

Overall Length	78.5
Seated Height	71.5
Diameter	22.2

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EDISWAN MAZDA

CRC 15/93

Vortexion quality equipment

The W.V.B. recorder has an additional amplifier and head with provision for "before" and "after" record monitoring while the recording is in progress, and this also has echo facilities.

The W.V.A. recorder has provision for a plug in stereo head and can be supplied with this and stereo playback pre-amplifiers with equalisation each having an output of 1 volt from a cathode follower. This is type W.V.A/S.

A heavy mumetal shielded microphone transformer is built in for 15-30 ohms balanced and screened line, and requires only 7 micro-volts approximately to fully load. This is equivalent to 20ft. from a ribbon microphone and the cable may be extended to 440 yds. without appreciable loss.

The 0.5 megohm input is fully loaded by 18 millivolts and is suitable for crystal P.U.'s, microphone or radio inputs.

The playback amplifier may be used as a microphone or gramophone amplifier separately or whilst recording is being made.

The meter fitted for reading signal level will also read bias voltage to enable a level response to be obtained under all circumstances. A control is provided for bias adjustment to compensate low mains or ageing valves.

The power output is 4 watts heavily damped by negative feedback and an oval internal speaker is built in for monitoring purposes.

THE VORTEXION W.V.B. or W.V.A/S

are eminently suitable for making a high quality recording almost indistinguishable from the original since these models have facilities for monitoring the recording actually put on the tape with only a fraction of a second delay.

By this means, when for any reason the signal is distorted or not as required, the result of the recording on the tape can be heard almost instantly, and adjustments can be made until the results are as required.

Many types of music today have the treble boosted considerably, and may result in greater power being recorded at high frequencies than at middle frequencies, an overload of the tape at high frequencies gives a mushy quality with lots of hiss and background noise.

Adjustment to the bias level while listening to the result is useful in this connection especially where the brand of tape and the bias setting for it are not exactly known.

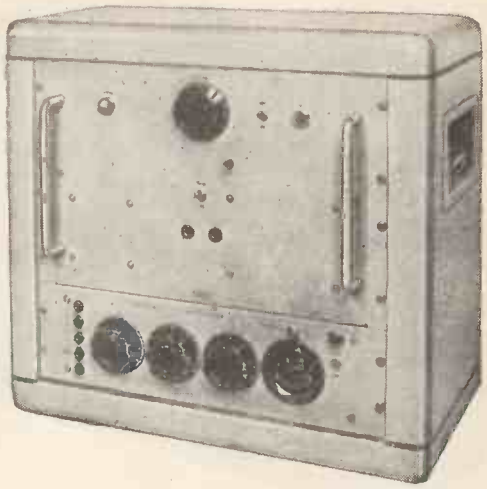
Again if clean treble recordings at $3\frac{3}{4}$in. are of prime importance it is now recognised that no other method is quite so effective in achieving this as reducing the bias slightly while listening to the results. The meter reading of the new bias setting for the particular tape used may be noted for future use.

VORTEXION LIMITED, 257-263 The Broadway, Wimbledon, London, S.W.19

Telephones: LIBerty 2814 and 6242-3. Telegrams: "Vortexion, Wimble, London."

Vortexion quality equipment

120/200 WATT AMPLIFIER



Will deliver 120 watts continuous signal and over 200 watts peak Audio. It is completely stable with any type of load and may be used to drive motors or other devices to over 120 watts at frequencies from 20,000 down to 30 cps in standard form or other frequencies to order. The distortion is less than 0.2% and the noise level —95 dB. A floating series parallel output is provided for 100-120 V. or 200-250 V. and this cool running amplifier occupies 12¼ inches of standard rack space by 11 inches deep. Weight 60lb.

30/50 WATT AMPLIFIER

Gives 30 watts continuous signal and 50 watts peak Audio. With voice coil feedback distortion is under 0.1% and when arranged for tertiary feedback and 100 volt line it is under 0.15%. The hum and noise is better than —85 dB referred to 30 watt.

It is available in our standard steel case with Baxendale tone controls and up to 4 mixed inputs, which may be balanced line 30 ohm microphones or equalised P.U.s to choice.

ELECTRONIC MIXER/AMPLIFIER

This high fidelity 10/15 watt Ultra Linear Amplifier has a built-in mixer and Baxendale tone controls. The standard model has 4 inputs, two for balanced 30 ohm microphones, one for pick-up C.C.I.R. compensated and one for tape or radio input. Alternative or additional inputs are available to special order. A feed direct out from the mixer is standard and output impedances of 4-8-16 ohms or 100 volt line are to choice. All inputs and outputs are at the rear and it has been designed for cool continuous operation either on 19 x 7in. rack panel form or in standard ventilated steel case.

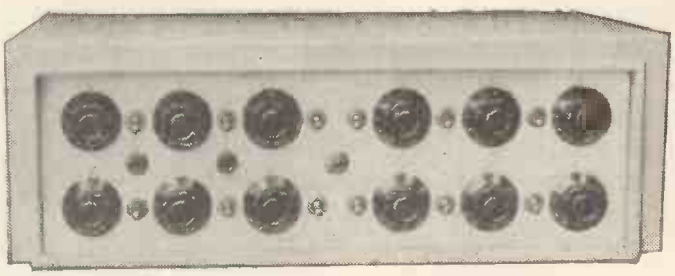
Size 18 x 7½ x 9½in. deep.

Price of standard model **£49.**

12-WAY ELECTRONIC MIXER

The 12-way electronic mixer has facilities for mixing 12 balanced line microphones. Each of the 12 lines has its own potted mumetal shielded microphone transformer and input valve, each control is hermetically sealed. Muting switches are normally fitted on each channel and the unit is fed from its own mumetal shielded mains transformer and metal rectifier.

Also 3-way mixers and Peak Programme Meters. 4-way mixers and 2 x 5-way stereo mixers with outputs for echo chambers, etc. Details on request.



Full details and prices of the above on request

VORTEXION LIMITED, 257-263 The Broadway, Wimbledon, London, S.W.19

Telephones : LIBerty 2814 and 6242-3

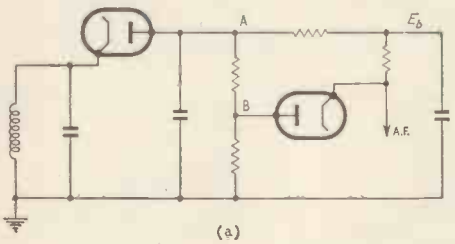
Telegrams : "Vortexion, Wimble, London."

Television history was made at night, at 10 p.m. to be exact, when a 45-second "live" Commercial was flashed across Europe from race-track to the screens of Britain's TV network within four hours of Stirling Moss winning the Monaco Grand Prix.

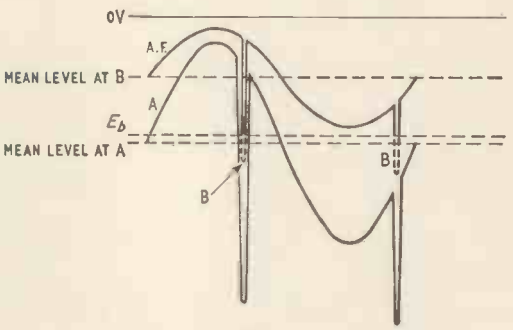
A telephone interview with the winning driver was recorded over land lines from Monte Carlo to the A.B.C. Studios, while photographs were wired to Fleet Street and rushed by motor-cycle to Teddington.

For permission to reproduce this picture of the editing of the interview we are indebted to The Dunlop Rubber Company Limited and Charles F. Higham Limited, their Advertising Agents, and to A.B.C. Television Limited, in whose Teddington Studios the photograph was taken.

Television Noise Limiting



(a)



(b)

The current November issue of ELECTRONIC TECHNOLOGY includes among other interesting articles one in which methods of noise limiting in the sound channel of television receivers are discussed. The author considers various well-known noise-limiting circuits, draws attention to some of their defects, and shows how they may be overcome to provide improved performance.

Design criteria and practical circuit details are given for a number of noise-limiting circuits and it is shown that a considerable improvement in noise suppression of an indifferent receiver can often be made without resorting to expensive and complicated circuitry.

ARTICLES IN THE DECEMBER ISSUE INCLUDE:

SWITCHING TRANSISTORS

Various methods used for predicting the performance of switching transistors are described in this article and their validity under conditions of large collector current is discussed. Different types of transistor are included and it is shown that, at high levels, evaluation of switching times in terms of the charge control is to be recommended with certain reservations.

TWO-SIGNAL BRIDGES

In this article the author shows that by a simple modification to the usual bridge-circuit arrangement it is possible for the input and output of the bridge to have a common terminal. This arrangement can also be used to reduce stray admittances and some arrangements enable the bridge to be remotely situated.

ELECTRONIC TECHNOLOGY *retains all the familiar features of* ELECTRONIC & RADIO ENGINEER *including the well-known Abstracts and References section. Regular readership will keep you in constant touch with progress in the entire field.*

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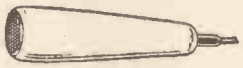

Model 39/1, this is ideal for tape or general amplifiers, complete with screened lead 39/6, plus 1/- post.

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12in. Hi-fidelity loudspeaker. High flux. Permanent magnet type with standard 3 ohm speech coil. Will handle up to 12 watts. Brand new by famous maker. Price 32/6, plus 3/6 post and insurance.

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POLYTHENE TAPE. 2in × 10 thou, for E.H.T. insulation up to 25 kV. 5/- per 12ft. roll.

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CELLULOSE CEMENT. Specially prepared for radio gluing of metal, glass, ceramic wood, fabrics, 4/6 per tin.

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Single and 2-gang types available, standard size with good length spindle, all new and boxed. Single types, 1/- each, values available: 5K, 10K, 25K, 50K, 100K, 250K, 1 meg., 2 meg. Gang type, 3/-, each, values available: 5K ± 5K, 100K ± 100K, ½ meg. ± ½ meg., 2 meg. ± 2 meg.

Hi-Fi Snip Infinite Wall Baffle

Nicely veneered and polished. Corner fitting (attaches to picture rail), Takes up no floor space. Gives really fantastic results with only low-price 8in. speaker Fitting for tweeter. Only 45/- each. carriage and insurance 3/6.

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CAR CHARGER RECTIFIER. Suitable for 6 or 12 volts up to 6 amps. 11/- post free.

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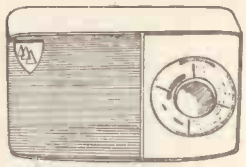
RESULTS GUARANTEED. Nothing can be more disappointing than to find that despite care in making up your little radio just will not work. This is unlikely to happen with our set, but if it does, you may send it in for service, we guarantee good results.



TWO MODELS

Pocket 4 uses three transistors and one diode and has refinements for receiving weak stations, price 42 6.

Every set complete to last nut and bolt, with proper case, tuning condenser and miniature loudspeaker.

Our sets do not need aerials, also they may be built in stages to car radio output. Post and insurance 2/6.

Pocket 5 uses 4 transistors approx. 3 times output with better tone, price 55/-.

PHILIPS TRANSCRIPTION UNIT

Philips AG 2009 Record Player, 4 speed, ideal for the enthusiast. Pick-up arm wired for stereo fine adjustment on all four speeds. Continuously variable pick-up weight (2-12 gms.) Supplied with Philips Hi-Fi crystal type AG3019 for micro-groove and 78 r.p.m. Frequency response 30-15,000 c/s Pick up lifting and lowering device. Individually balanced heavy turntable. Muting switch. Can be used with any amplifier or radio set. Complete with monaural pick-up £10/10/0 or 2 Gns. deposit and 20 fortnightly payments of 10/-. Available also with stereo head, diamond or sapphire stylus. Prices on request.

THE TAYLOR METER MODEL 127A

A pocket size meter but with a big scale and a sensitivity of 20,000 Ohms per volt D.C., therefore an ideal unit for television servicing—robustly made and complete with leads and prods—20 ranges as follows:

D.C. current 50 micro-amps, to 1 amp.

D.C. voltages—0-1,000 volt in seven ranges (25 KV with external probe, optional extra).

Volts A.C.—0.2,500 in six ranges.

Ohms—0 20 meg. Ohm in three ranges (self-controlled) Self-contained 3¼in. movement. Price £10 or 10/- deposit and 23 fortnightly payments of 10/-. Non-callers add 5/- carriage and insurance.

COMPONENTS FOR TRANSISTOR SETS

Parts for "Practical Wireless" Pocket Transistor Radios available. Send for lists.

Sub-miniature Electrolytics. 1 mfd. 18v., 2.5 mfd. 6v., 4 mfd. 6v., 8 m'd. 6v., 5 mfd. 12½v., 10 mfd. 6v., 25 mfd. 6v., 30 mfd. 3v., 50 mfd 3v., 200 mfd. All 1/9 each.

Transistor Ferrite Rod Aerial with medium and long wave coils with circuit. Price 7/6.

Oscillator Coil and set of 3 I.F.transformers for transistor set with circuit. Price 23/6.

Midget 3in. P.M. Loudspeaker for transistor set. 3 ohm or 80 ohm coil. Price 18/6.

Midget 208 pF + 176 pF two-gang Tuning Condenser with trimmers, ¼ spindle drilled and tapped. Price 9/-, plus 1/- post.

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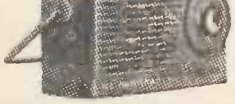
Push-pull Input Transformer to match the above Output Transformer, 8/6.

0.0005 mfd. Single Tuning Condenser. Solid di-electric ¼in. spindle for transistor or crystal set. 3/9; ditto with spindle tapped 6 BA. 4/-.

Transistors tested. Set of six for Superhet includes matched pair, Mullard 23/10/0, ditto unbranded. 45/-; suitable as mixers, 9/6 each. Suitable as I.F. amplifiers, 8/6; suitable for R.F. and Regen. circuits, 6/6; matched pairs for Push-pull Output, 16/- per pair. High gain for single ended output. 7/6. Ordinary white spot. 3/9; red spot. 3/6.

Resistors, miniature quarter watt type for transistor sets. All popular values, 5d. each.

Miniature ceramic condensers 6d. each.



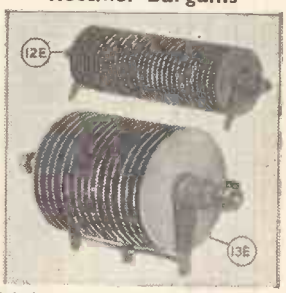
Transistor Set Cabinet

Very modern cream cabinet, size 5½ × 3 × 1½ in. with chrome handle tuning knob and scale. Price 7/6, plus 1/6 postage and packing.

Connecting Wire

P.V.C. covered in 100ft. coils—2/9 a coil or four coils different colours, 10/- post free.

Rectifier Bargains



Selenium rectifier type 12, 500 v. ½ A. half-wave, easily rebuilt into full wave or multiple type, contains 30 35 mm. discs. Price 8/6, plus 1/6 post. Type 13. 36 volt 9 amp. easily rebuilt into six full wave charger rectifiers suitable for 6 or 12 volt batteries. 3 amps, contains 24 84 mm. discs. Real bargains at 19/6, plus 1/6 post.

Band III Converters

Suitable Wales, London, Midland, North Scotland, etc., All the parts, including 2 EF80 valves, coils, fine tuner, contrast control, condensers and resistors. (Metal case available as an extra). Price only 19/6, plus 2/6 post and insurance. Data free with parts or available separately, 1/6. Please send two more kits, the one you sent last week is performing magnificently. We receive this sort of letter every day of the week, so if you have hesitated because you thought our kits too cheap you need hesitate no longer.

Miniature Microphone

American made. Dynamic type, real bargain at 2/6, plus 6d. postage.

Building A Scope?

3in. oscilloscope tube. American made type No. 3FP7, octal base 6.3 v. .6 amp. heater, electrostatic deflection, brand new and guaranteed, with circuit diagram of scope. 15/- each, plus 1/6 post and insurance.

Wrap our heater wire (blanket wire) around the pipes in your loft, to prevent freeze-ups Complete blanket wire suitable for up to 30ft. of pipe 10/- post free. With instructions.

ELECTRONIC PRECISION EQUIPMENT, LTD.

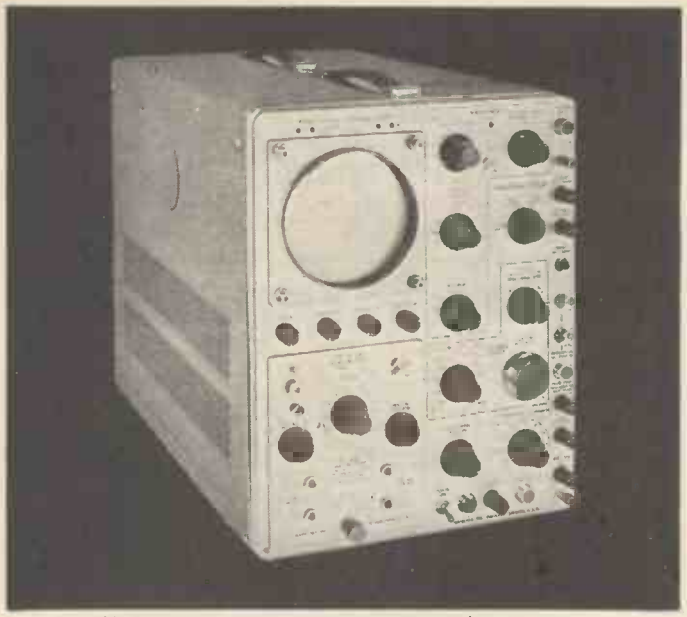
post orders are dealt with from Eastbourne, so for prompt attention please post your orders to 66 Grove Road, Eastbourne, marked Department 2. Callers may use any one of the Companies below.

Electronics (Croydon) Ltd.,
266 London Road,
Croydon.
Phone: CRO 6558.
Half day, Wednesday

Electronics (Finsbury Park), Ltd.,
29 Stroud Green Road,
Finsbury Park, N.4.
Phone: ARChway 1049
Half day, Thursday

Electronics (Manor Park) Ltd.
520 High Street North,
Manor Park, E.12.
Phone: ILFord 1011
Half day, Thursday

Electronics (Ruislip) Ltd.,
42-46 Windmill Hill,
Ruislip, Middx.
Phone: RUISLIP 5780
Half day, Wednesday



"The 545" has set a new standard in wide band measuring Oscilloscopes.

OUR FIRST CONSIDERATION—

the *right* instrument for your application

IN THE FIELD OF OSCILLOSCOPES, Livingston Laboratories offer a unique service in the form of expert advice in the choosing of equipment to meet your needs. The relevant factors are not who makes it or where it is made, but will it do the job? Livingston Laboratories are sole representatives in Great Britain of Tektronix. When top performance oscilloscopes are required, the range of Tektronix instruments can satisfy the most rigorous demands.

FOUR MORE FROM THE TEKTRONIX RANGE

Dual Beam Oscilloscope, Type 502

True dual Beam differential display at 200μV to 20V/cm from D.C. to 100 kc/s. Band width increases as sensitivity is reduced.
Full sensitivity X-Y facility.
Specially suitable for electro - medical and similar work.

"X - Y" Oscilloscope, Type 536

Identical X & Y axes D.C.—10Mc/s, 0.03μsec. risetime.
Relative phase shift less than 1° to 15Mc/s.
Linear sweep with type T time base plug-in unit.

TEKTRONIX

Dual Beam Oscilloscope, Type 551

True dual Beam D.C.—25Mc/s.
Signal Delay 0.2μsec. both channels.
Linear sweep 20mμsec. to 5 sec/cm calibrated.
Single sweep lock out reset circuitry.
4 *Channels*, D.C.—22 Mc/s with two 53/54C units. 10Kv *E.H.T.* enables single shot recording.

Transistor Curve Tracer, Type 575

C.R.T. Display of families of N.P.N. or P.N.P. Characteristic curves.
Collector sweep 200 volts at 1A, 20 volts at 10A positive or negative.
Base or Emitter Step Generator 4-12 steps at 1μA to 0.2A per step. 5 constant voltage/step divisions. Polarity negative or positive.
X and Y axes calibrated ± 3%.

Extend your oscilloscope facilities with these new Tektronix Plug-in Units

TYPE S—Converts Types 540 and 550 Series to display semi-conductor diode switching characteristics and to measure:—
Effective lifetimes to 2 nanoseconds
Stored charge to 10 picocoulombs
Junction capacitance to 2 picofarads
Base resistance to 0.25 ohm.

TYPE Q—Plugs into any Tektronix Plug-in Oscilloscope to provide information from strain gauges and many resistive, capacitive and inductive transducers plotted against time.

Full details of Tektronix Equipment from sole distributors:

LIVINGSTON LABORATORIES LTD

RETCAR STREET · LONDON · N.19 Telephone: Archway 6251

Hewlett-Packard

Oscillators

for frequencies 0.008 cps to 10 MC

-hp- 650 A Test Oscillator

-hp- 650 A Test Oscillator

One of the most popular -hp- oscillators is Model 650 A, 10 cps to 10 MC, a highly stable instrument for audio, supersonic, video and RF measurements. Output is flat within 1 db full range, voltage range 0.00003 to 3 V. Distortion less than 1 % to 100 KC.

Hewlett-Packard offers you 13 high-quality, very accurate oscillators. Each uses the resistance-capacity circuit pioneered by Hewlett-Packard – the circuit that makes possible high stability, wide range, compact and rugged instruments. These dependable oscillators are simple to operate and require no tiresome resetting or adjustment during operation.

Many world-famous Hewlett-Packard laboratory instruments are now made in the new Hewlett-Packard GmbH plant at Böblingen, near Stuttgart. Here quality engineering and latest manufacturing techniques bring you instruments of exceptional performance at moderate price.

Instrument	Primary Uses	Frequency Range	Output	Price
-hp- 200 AB	Audio tests	20 cps to 40 KC	1 watt / 24.5 V	£ 62
-hp- 200 CD	Subsonic through supersonic audio and ultrasonic tests	5 cps to 600 KC	160 mW or 10 V / 600 ohms; 20 V open circuit	£ 69
-hp- 200 J	Interpolation, frequency measurements	6 cps to 6 KC	160 mW / 10 V	£ 123
-hp- 200 SR	Driving -hp- 739AR Frequency Response Test Set	.5 cps to 600 KC	3 V rms into 50 ohms	£ 76
-hp- 200 T	Telemetry, carrier current tests	250 cps to 100 KC	160 mW or 10 V / 600 ohms; 20 V open circuit	£ 185
-hp- 201 C	High quality audio tests	20 cps to 20 KC	3 W or 42.5 V / 600 ohms	£ 93
-hp- 202 A	Low frequency measurements	0.008 to 1200 cps	28 mW or 30 V p-p / 4000 ohms	£ 216
-hp- 202 C	Servo equipment tests, measurements	1 cps to 100 KC	160 mW or 10 V / 600 ohms	£ 119
-hp- 205 AG	High power audio tests, gain measurements	20 cps to 20 KC	5 watts	£ 205
-hp- 206 A	High quality, high accuracy audio tests	20 cps to 20 KC	+ 15 dbm	£ 308
-hp- 207 A	Audio sweep generation	20 cps to 20 KC	160 mW or 10 V / 600 ohms	£ 134
-hp- 233 A	Carrier oscillator – current tests	50 cps to 500 KC	3 W / 600 ohms	£ 205
-hp- 650 A	Wide range video tests	10 cps to 10 MC	15 mW / 3 V	£ 201

Prices delivered U. K. exclusive of duty where payable. Continuous progress in design may affect the above specifications which are therefore subject to change without notice.

For information, technical sales and engineering help, or a demonstration please write or call

Hewlett-Packard S.A.

Geneva (Switzerland) Rue du Vieux-Billard 1, Tel. (022) 26 43 36

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LIVINGSTON LABORATORIES LTD.
RETCAR STREET, LONDON, N. 19

Telephone: ARChway 6251 HSPA - 1 - 412

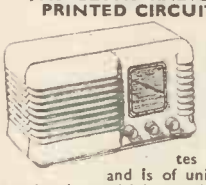
leads the way

SEE OVERLEAF FOR MORE NEWS FROM LASKY'S RADIO

"FAMILY FOUR" (5)

Our supersensitive T.R.F. Receiver for home construction. Covers Long and Medium Wavebands, is housed in very smart plastic table cabinet in Brown or Black. For A.C. mains 200/250 v. Comprehensive assembly instructions provided, including practical and theoretical diagrams, which are easy to follow and will enable you to complete this receiver which will be the envy of your friends. ALL NECESSARY COMPONENTS ARE BEING OFFERED FOR LIMITED PERIOD ONLY AT THE REMARKABLE PRICE OF ONLY 79/6, plus 2/6 P. & P. Instruction book available separately if you wish to study before purchase at 1/6 post free.

THE CLYNE RADIO "DE LUXE" PRINTED CIRCUIT SUPERHET



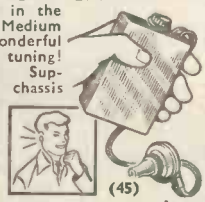
A new two-wave band (L and M) Superhet using the latest miniature valves: ECH81, EF85 and ECL80, plus contact cooled Rectifier. Incorporates Ferrite Rod Aerial and is of unit construction. Exceptional sensitivity and selectivity. Outstanding performance and quality T.C.C. condensers throughout. Easily constructed in one evening. Brown or ivory Bakelite or wooden Walnut finish cabinet. A.C. mains 200/250 v. All necessary components at special inclusive price of £7/19/6 plus 3/6 P. & P. Instruction Book with itemised price list available separately at 1/6 post free. Also available in De Luxe Cabinet (as "Economy Four" at 5/- extra).

SUPER PERSONAL PORTABLE. (32) & (33)

A wonderful little set that you can take anywhere. Ideal for camping, picnics, etc. Detachable aerial rod supplied. Covers Medium waveband 200-500 metres. Can be built in approx. 1 hour. All necessary components available at the following SPECIAL INCLUSIVE PRICES: 1-valve version **ONLY** 35/- plus 2/- P. & P. Super 2-valve version **ONLY** 41/-. Plus 2/- P. & P. Send for point-to-point wiring diagram and parts price list 2/- post free. Extra for use with the above DLR5 balanced armature headphones, 7/6 pair.

NEW! "PAGEBOY" 2-TRANSISTOR POCKET PORTABLE

Completely portable—NO EXTERNAL AERIAL OR EARTH REQUIRED. This is an amazing little receiver with built-in aerial and small enough to be held in the palm of the hand. Medium wave reception at wonderful volume. No fiddley tuning! —condenser tuned! Supplied with drilled chassis and colour coded components. Easily assembled with the aid of the easy-to-follow assembly instructions provided. Total cost of all necessary components, including transistors, wiring wire and even solder **ONLY** 32/6 plus 1/6 P. & P. Battery 3/- extra. Ardente type deaf-aid earpiece complete with cord and plugs extra at 12/6. Parts price list and Easy Lay-out Plans 2/- post free. Callers welcome to hear this set demonstrated at any of our branches. Our reputation is your guarantee.



(45)

THE "WAVEMASTER" 7-TRANSISTOR LUXURY PORTABLE

400 MILLIWATTS OUTPUT

(43)

To build yourself Medium and Long waves—Push-Pull Superhet A.V.C. Perfect Car Radio reception. Size 10in. x 6¾in. x 4¼in. at base tapering to 4in. at top.

Very attractive two-tone grey Vynide covered cabinet with black and gold printed escutcheon plate, cream and gold knobs, handle and cabinet fittings. ★ Weight—complete with long-life 7½ volt battery—4½lb. ★ Mazda high-grade transistors throughout. ★ High-Flux 7in. x 4in. Elliptical Speaker. ★ Slow motion tuning. ★ Co-axial socket at rear for direct connection to Car Radio Aerial. ★ Improved reception by use of seven-section plated telescopic aerial disappearing into Cabinet when closed, 34in. above Cabinet when fully extended.

Construction simplified by Bakelite chassis board with the following components already mounted: I.F. Transformers (3). Oscillator Coil, Trimmer Bank, Output Transformer, Interstage Transformer, Aerial Brackets and Earth Bar. SPECIAL INCLUSIVE PRICE for all required components, full assembly instructions—nothing more to buy—is £10/19/6 plus 3/6 P. & P. Alignment service available. Full assembly instructions and individually priced parts list, all of which are available separately, 2/6, post free.

TO BUILD YOURSELF

ALL PARTS AVAILABLE SEPARATELY

"PRACTICAL WIRELESS" POCKET SUPERHET All required Components for the Pocket Superhet as described in November issue of "Practical Wireless" now available at special inclusive price of £9/15/6 complete, including Printed Circuit. All items available separately, send stamp for list.

	All required components at special Inclusive price	P. & P.	Instruction Book and itemised price list available separately
(1) New Look "RAMBLER all dry s'het portable. **NEW LOW PRICE**	£6 19 6	2/6	1/6
(2) "RAMBLER" Mains Unit (suits most portables)	£2 7 6	1/6	9d.
(3) "ECONOMY FOUR" T.R.F. Mains Receiver	£5 5 0	2/6	1/6
(4) "ECONOMY FOUR" with New Look Cabinet	£5 10 0	2/6	1/6
(5) "FAMILY FOUR" (our new T.R.F. Receiver)	£3 19 6	2/6	1/6
(6) "SUPERIOR FOUR" (four valve mains receiver)	£5 15 0	2/6	1/6
(7) Standard JASON F.M. Tuner FMT1	£6 15 0	2/6	2/-
(8) Fringe area JASON F.M. Tuner FMF	£7 15 0	2/6	2/-
(9) JASON "MERCURY 2" Switched F.M. Tuner plus ITA/B.B.C. Sound	£10 10 0	2/6	3/6
(10) OSRAM 912 Printed circuit F.M. Tuner. **NEW LOW PRICE**	£5 19 6	2/6	2/6
(11) JASON "ARGONAUT" AM/FM Chassis	£15 5 0	2/6	2/-
(12) JASON "ARGONAUT" AM/FM Tuner	£13 19 6	3/6	2/-
(13) F.M. Power Pack (suitable for most tuners)	£1 17 6	1/6	1/-
(14) R.C. 3/4 watt Amplifier (with Bass, Middle and Treble controls)	£4 5 0	2/6	1/-
(15) 2-amp. Battery Charger	£1 16 6	2/6	3d.
(16) R.C. Transistor/Crystal Receiver ('phones extra)	£1 1 0	1/3	3d.
(17) R.C. Super Transistor/Crystal Rec. (ditto)	£1 7 6	1/3	3d.
(18) R.E.P. 1-valve Battery Receiver	£2 2 0	2/-	9d.
(19) "CRY-BABY" ALARM (Baby Alarm)	£3 12 6	2/6	1/-
(20) MULLARD 510 Amplifier (printed circuit) Ultra Linear Version	£9 9 0	3/6	1/6
(21) MULLARD 510 as above plus input selector and spare power supplies	£11 10 0	3/6	2/6
(22) "DE-LUXE" Printed Circuit Superhet	£7 19 6	3/6	1/6
(23) "DE-LUXE" with New Look Cabinet	£8 4 6	3/6	1/6
(24) JASON J.T.V. 2 Tuner	£13 19 6	3/6	2/6
(25) RADIO JACK	19 6	1/6	6d.
(26) MULLARD TYPE "C" Tape pre-amp.	£12 9 6	3/6	2/6
(27) JASON WII Wobbulator	£14 19 0	3/6	3/6
(28) JASON Valve Voltmeter EM10 (23 ranges)	£18 10 0	3/6	2/6
(29) NEW JASON F.M. TUNER FMT2 with built-in power supplies and cabinet	£8 19 6	3/6	2/6
(30) NEW JASON FRINGE F.M. TUNER FMT3, as above	£10 19 6	3/6	2/6
(31) PULLIN Series 90 TEST METER	£5 19 6	2/6	1/6
(32) R.C. Super Personal Portable 1-valve (phone extra)	£1 15 0	2/6	2/-
(33) R.C. Super Personal Portable 2-valve (phone extra)	£2 1 0	2/6	2/-
(34) R.C. TRANSETTE 2-Transistor Personal Portable	£3 9 6	2/-	2/-
(35) JASON EVEREST 6-Transistor 2-wave Portable	£13 19 9	3/6	3/6
(36) JASON EVEREST 7-Transistor 2-wave Portable	£15 18 9	3/6	3/6
(37) CLYNE Cathode Ray Oscilloscope	£12 19 6	5/-	10/-
(38) Compact Multi-range Test Meter	£2 19 6	1/6	1/6
(39) CAR RADIO, Printed Circuit, 5-valve S'het. **NEW LOW PRICE**	£11 19 6	3/6	2/6
(40) JASON Audio Generator AG10	£14 5 0	3/6	2/6
(41) JASON Oscilloscope OG10	£22 10 0	5/-	3/6
(42) Super SHORT WAVE RADIO, 1 valve	£1 15 0	2/-	2/-
(43) "WAVEMASTER" 7-Transistor Luxury Portable	£10 19 6	3/6	2/6
(44) "GOLD STAR" De-Luxe 1-valve Portable	£1 17 6	2/6	1/6
(45) "PAGEBOY" 2-Transistor Pocket Portable ('phone extra)	£1 12 6	1/6	2/-

Instruction Books which contain full description, easy-to-follow practical wiring diagrams theoretical diagrams itemised price lists, etc., are free of charge with all parcels but may be purchased separately as shown above.

PLEASE NOTE:—A selection of the above items are described more fully in this advertisement!!

PRINTED CIRCUIT CAR RADIO

(39)

(for Home Construction). We are proud to be able to offer this New type Car Radio employing up-to-the-minute circuitry, special 12 volt valves and transistorised out-put stage. The highest degree of sensitivity is assured by the incorporation of Permeability Tuning and a tuned R.F. Stage. Covers Medium and Long Wavebands. NO VIBRATOR PACK IS REQUIRED. This is a really compact receiver that will fit any car. Comprehensive assembly Instructions are provided with all necessary components, including valves and transistor at a Special New Low inclusive Price of Only £11/19/6 plus 3/6 P. & P. Instruction booklet with itemised price list, full description dimensions, etc., available separately at 3/6 post free.

● TURN OVER FOR MORE CLYNE BARGAINS➔

CLYNE RADIO LTD. THE COMPONENT SPECIALISTS

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162 Holloway Road, London, N.7.
99 Cheapside, London, E.C.2.

★ MORE CLYNE RADIO BARGAINS ★

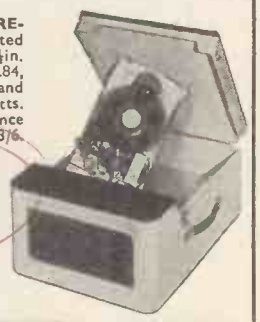
CABY UNIVERSAL TEST METERS
These pocket-size multi-range test meters are of excellent quality and cover all the most useful ranges (A.C. Volts, D.C. Volts, resistance and current). Supplied complete with test prods, instruction book and batteries. Model A.10 (2,000 ohms per volt) £4/17/6
Model B.20 (10,000 ohms per volt) £6/10/-.
Plus P. & P. 3/6 on each.
Fully detailed and illustrated leaflet available on request

RECORD PLAYERS
Full range at usual competitive prices. Interesting H.P. facilities E.M.I. 4-SPEED STEREO/MONAURAL SINGLE RECORD UNIT. Complete with Stereo Head and Sapphire Styli. Brand New and Fully Guaranteed. **ONLY £6/19/6** plus 3/6 P. & P.

JUST ARRIVED!
LATEST GARRARD MODEL 210. Four-speed manual or automatic. 10in. and 12in. records of same speed can be mixed in any order, wired for stereo, attractive white colour scheme. Price 10½ gns. plus 3/6 P. & P.
LATEST B.S.R. UA14. 4-speed. Attractive appearance. Wired for stereo. Fully guaranteed. **£7/19/6.** plus 3/6 P. & P.
B.S.R. UA8 STEREO/MONAURAL. Few only at **£7/19/6,** plus 3/6 P. & P. Brand new Guaranteed.
COLLARO CONQUEST. 4-speed. Wired for stereo. Brand new. **£7/19/6,** plus 3/6 .P. & P
No. 38 AFV WALKIE-TALKIE. A wonderful offer. This famous trans-receiver unit, with relay operated SEND/RECEIVE switch covering 7.4-9 Mc/s band, range approx. 5 miles. Good condition. ONLY **22/6** plus 2/6 P. & P. per unit (less accessories). Quantity export inquiries welcomed.
AERIAL TUNING UNIT ZA.0841. This well made ex-W.D. unit contains a host of useful components including: 1 mA. 2in. flush round M/C meter, 1 mA. Westinghouse full-wave meter rectifier, 5-pole 5-way heavy-duty silver plated wavechange switch. 3in. dia. silver plated rotary tuning indicator. 350 pF tuning condenser with insulated coupler and 3½in. calibrated dial (0-180 deg) etc. etc. Contained in strong metal carrying case 9in. x 9in. x 8in. with hinged lid. ONLY **27/6** plus 5/- C. & P.
A CONSTRUCTOR'S MUST
The latest " Pifco " Instrument Bit Soldering Iron
With integral Stand and built-in Spot-light for illuminating work 200/250 v. ONLY 22/6. P. & P. 1/6.
SOLDER. New boxed 1 lb reels, 16 S.W.G. 50/50 at **8/6** only, plus 1/- P. & P.
VIBRATOR PACKS. Limited quantity of both 6 volt and 12 volt types available. Output 300 volt. 100 m/a. Fully smoothed. Brand new ex-Govt. surplus. Price 35/- ea., plus 2/6 P. & P. Please specify input voltage required.
12 VOLT VIBRATOR PACK. (Mallory). Output 150 v. @ 40 mA. Complete with synchronous vibrator. Brand new. **ONLY 12/6,** plus 2/- P. & P.
12in. BAKERS SELHURST LOUDSPEAKER. 15 ohms, 15 watt 30-14,000 cps. Brand new, **£4/10/-.** P. & P. 3/6.
12in. RICHARD ALLAN P.M. LOUDSPEAKER. 3 ohm speech coil. Brand new. Only **32/6** plus 2/6 P. & P.
DEAF AID TYPE EARPIECES. Ardente Standard magnetic type complete with lead and plug. Only **12/6.** P. & P. 1/-.

SUPER MAGNETIC RECORDING TAPE SPECIAL!!!
Famous American Ferrodynamics **"BRAND FIVE"** An enthusiast's "must." Brand new (NOT SUB-STANDARD) High grade Acetate Base, 5in. 600ft. **16/-,** 5in. 900ft. **18/6,** 5½in. 1,200ft. **23/6,** 7in. 1,200ft. **25/-,** 7in. 1,800ft. **35/-.** Extra quality Mylar Dupont. 5in. 1,200ft. **37/6.** 7in. 1,800ft. **44/-.** 7in. 2,400ft. **60/-.** Each on plastic spool. P. free. *Trade enquiries invited.*

EXTRA SPECIAL OFFER !!
A small three-valve **PORTABLE RECORD PLAYER AMPLIFIER** mounted on baffle 12 x 7in., with High Flux 6½in. Loudspeaker. Valve line-up ECC83, EL84, EZ80. Incorporates separate bass and treble controls. Max. output 3 watts. Will match all types of high impedance pick-up. Ready to use, **£5/12/6.** P. & P. 3/6.
NEW STYLE CABINET finished in two-tone Leatherette. Will accommodate above Amplifier and Baffle without modification, also most types of Ancillary Equipment. Overall size 18 x 13½ x 8½in. Fitted with carrying handle, **£3/9/6** plus 5/- P. & P.
NOTE. If both items purchased together they will be supplied at a special inclusive price £8/7/6 plus 6/6 P. & P.



★ **TAPE RECORDER CONSTRUCTORS** ★
★ *FOR THE CONNOISSEUR* ★
COLLARO TAPE TRANSCRIPTOR Mk. 4. 3-speeds, fitted with digital counter. List price **£25.** Our Price **£17/10/-.** P. & P. 5/-.
COLLARO TAPE PRE-AMPLIFIER AND BIAS OSCILLATOR. Complete with power pack for use with the above deck. 4 valve plus EM81 magic eye. 110-240 v. A.C. Input sensitivity: microphone socket 5 m/v., auxillary socket 500 m/v. Speed equalisation switch gives compensation at all 3 speeds. Full wiring instructions included. List price £21. Limited quantity only at **£15/19/6.** P. & P. 5/-.
LATEST COLLARO STUDIO TAPE TRANSCRIPTOR. 3 motors, 3 speeds, 1⅞, 3¾, 7½ i.p.s. takes 7in. spools. Push-button controls, **£12/19/6** plus 5/- P. & P. Usual H.P. facilities.
LATEST B.S.R. " MONARDECK." Single speed Tape Deck. Takes 5¾in. spools—3¾ i.p.s. At only **£8/19/6** plus 5/- P. & P.
TAPE RECORDER AMPLIFIER—MANUFACTURER'S SURPLUS: Suitable for use with either of the above Tape Decks, and most other types. For A.C. mains, 4 watts output. 40-12,000 CPS at 7½ i.p.s. ± 3 db. Facilities for superimpose. Valves: ECL82, 12AX7, EM84, and contact cooled metal rectifier. Radiogram input, microphone input, volume control and separate treble and bass controls. Chassis measurement 11½ x 3 x 4¾in. Supplied complete with attractive grey/blue escutcheon plate finished in black and gold. Circuit diagram and connecting instructions included. Price **£10/10/-** only, plus 3/6 P. & P. Limited quantity. If purchased with either of the above decks, both items post free!
ATTRACTIVE TWO-TONE PORTABLE CARRYING CASE Suitable for above amplifier and Collaro, Studio deck. Limited quantity only at **72/6** plus 3/6 P. & P.
MIC 45-1 Acos latest flat pistol-grip crystal microphone. Attractive black and gold finish. OUR PRICE **29/6** plus 1/- P. & P.
ACOS MIC 39-1. Crystal stick microphone. List price 5 gns. Our price **39/6** plus 1/6 P. & P.
MIC 40. General purpose crystal microphone with desk stand. Our price **25/-** only plus 1/6 P. & P.
M.C.24. Imported, crystal, attractive streamlined polished metal case, incorporates muting switch. List price 64/-. OUR PRICE **42/-** only. 1/- P. & P.
ANOTHER HAND MIKE BARGAIN! Lightweight crystal with built-in desk stand at only **19/6.** P. & P. 1/-.

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MODEL U.1 MULTI-RANGE TEST-METER. Ideal for amateurs and service engineers. Incorporates 3 inch rectangular meter. Ranges: A.C. and D.C. voltage. 0-10-50-250-500-1,000 v. D.C. current 0-100-500 m/a. 0-1 m/a. (used at 0-10 v. range). Resistance 1-2,000 ohms (centre 24 ohms). 100-200,000 ohms (centre 2.4 k.). Sensitivity 1,000 ohms per volt A.C. and D.C. Size: 5in. x 3in. x 2½in. Weight 22 ozs. only. Fully guaranteed. Supplied complete, and ready to use with test leads, at the very low price of only **79/6** P. & P. 3/6.
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Valve line-up: 6K8G, 6K7G, 6Q7C 6F6G, 6X5G and 6 volt 4-pin non-synchronous vibrator. 8in. P.M. Speaker, 4 watts output, P.U. socket Ext. L.S. socket, etc. Tone control. Fitted in polished wood cabinet, size 21¾in. x 10¼in. x 10¼in. These cabinets are slightly soiled owing to storage, but each is guaranteed unused, in serviceable condition, tested prior to despatch. Price **£5/19/6** only plus P. & P. 7/6, plus 27/6 for A.C. Mains Conversion Components if required. **OUTSTANDING BUY!**
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AVOMETER MODEL D

£8.19.6 (*P. & P. 3/6*)

D.C. Volts	A.C. Volts	D.C. Current	A.C. Current
105 mV.	7.5 V.	15 m/A.	75 m/A.
300 mV.	15 V.	30 m/A.	150 m/A.
1.5 V.	75 V.	150 m/A.	750 m/A.
3 V.	150 V.	300 m/A.	1.5 Amps.
15 V.	300 V.	1.5 Amps.	7.5 Amps.
30 V.	600 V.	3 Amps.	15 Amps.
150 V.	750 V.	15 Amps.	
300 V.	1.5 KV.	30 Amps.	Resistance
750 V.			0-1000 ohms
1.5 KV.			0-10 K ohms

Thoroughly overhauled. Complete with batteries and instructions. An extremely robust meter at a very reasonable price.

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PV1-35 32/6, 2D21 7/6, OC3 6/-, PT15 12/6, CV51(Y65) 5/-, 6F33 5/-. BRAND NEW in individual cartons. Bulk enquiries invited.

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A high quality 3 ohm unit fitted into heavy gauge black crackled steel cabinet, size 10½ x 11½ x 6in. Fitted with rubber feet and 6ft. lead. Ideal for extension speaker. CR 100, etc. In original cartons. BRAND NEW. **45/-.** Post 3/6.

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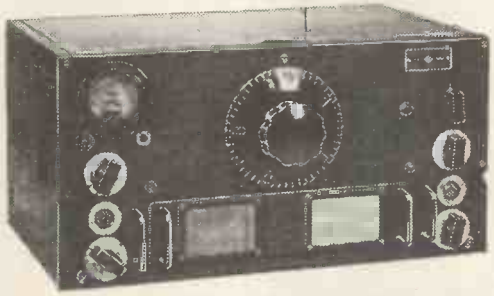

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IDEAL FOR CROWD CONTROL, FACTORIES, FETES, ETC. CONSISTS OF 4 SPEAKER UNITS AND CONTROL UNIT. COMPLETE WITH MICROPHONE, HEADPHONES AND SPARES. OPERATES FROM 12 VOLTS D.C. (OR 6 VOLTS A.C. WITH SLIGHTLY REDUCED OUTPUT) CONSUMING ONLY 3 AMPS. OUTPUT POWER 8 WATTS. ALL TESTED AND WORKING, BUT SLIGHTLY SOILED. A GENUINE BARGAIN. £4/19/6. CARRIAGE 26/8.

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Contains 100 ¼ and 1 watt resistors, 50 Hi Stab resistors, wire wound resistors, carbon and W/W pots, 100 capacitors (mica, paper, Sprague, bias, variable, etc.), valveholders, tag strips, metal rectifiers, sleeving, etc. All components are unused. **GUARANTEED VALUE, 25/-** plus 2/6 post.

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A crystal controlled heterodyne wavemeter covering 500 Kc/s. to 10 Mc/s. (Harmonics up to 30 Mc/s.) Requires 300 V. 15 mA. and 12 V. 0.3 a. D.C., but can be easily modified for 120 V. and 1.4 V. working. Size 7 x 7½ x 4in. Good condition, complete with valves, crystal, instruction manual and circuit. ONLY **59/6.** Post 3/6. This item available complete as above. **BRAND NEW** and with spare set of valves. **£4/10/-,** post 3/6.

CANADIAN CRYSTAL CALIBRATOR. Uses double crystal and multivibrator circuit to give "pips" at 1 Mc/s., 100 Kc/s. and 10 Kc/s. Incorporates Modulator. Handbook supplied. **79/6.** Post 2/6.

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D.C./A.C. CONVERTERS. Input 12 v. D.C. Output 230 v. 50 c/s. A.C. at 135 watts. Fitted with 0–300 v. A.C. 2½in. meter and slider resistor for voltage adjustment. In stout wooden carrying case with lid. Perfect working order. **£9/19/6.** Carr. 10/6.
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R.C.A. 0-500 microamps. 2½in. circular flush panel mounting. Dials are engraved 0–15, 0–600 volts. As used in the American version of the No. 19 set. BRAND NEW. Boxed. **15/-.**

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0–300 volts, 25–100 c/s. Moving iron, 6in. scale. Fl. mtg. Hermetically sealed, grade IN. Made 1955. BRAND NEW. Boxed. **79/6.** Post 3/6.

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COMPLETE KIT OF PARTS

Designed by MULLARD—presented by STERNS strictly to specification

MULLARD "5-10" MAIN AMPLIFIER

For use with the MULLARD 2-stage pre-amplifier with which an undistorted power output of up to 10 watts is obtained. We supply SPECIFIED COMPONENTS AND NEW MULLARD VALVES including PARMEKO MAINS TRANSFORMER and choice of the latest Ultra-linear PARMEKO or the PARTRIDGE Output Transformer.

Price: COMPLETE KIT (Parmeko O/put Trans.)..... **£10.0.0**

Alternatively we supply ASSEMBLED AND TESTED **£11.10.0**

ABOVE INCORPORATING PARTRIDGE OUTPUT TRANSFORMER £1/6/- extra

MULLARD'S 2-VALVE PRE-AMPLIFIER TONE CONTROL UNIT

Employing two EF86 valves and designed to operate with the Mullard MAIN AMPLIFIER, but also perfectly suitable for other makes.

Supplied strictly to MULLARD SPECIFICATION and incorporating:

- Equalisation for the latest R.I.A.A. characteristics.
- Input for Crystal Pick-ups and variable reluctance magnetic types.
- Input (a) Direct from High Imp. Tape Head. (b) From a Tape Amplifier or Pre-Amplifier
- Sensitive Microphone Channel
- Wide range BASS and TREBLE Controls.

Price: COMPLETE KIT OF PARTS **£6.6.0** ASSEMBLED AND TESTED **£8.0.0**

COMPLETE MULLARD 5-10 AMPLIFIER

The popular and very successful complete "5-10" incorporating Control Unit providing up to 10 watts high quality reproduction.

Specified components and new MULLARD VALVES are supplied including PARMEKO MAINS TRANSFORMERS and choice of the latest PARMEKO or PARTRIDGE ULTRA Linear Output Transformers.

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Hire Purchase (Assembled Amp. only). Deposit £2/14/-, 12 months at 19/10.

ABOVE incorporating PARTRIDGE OUTPUT TRANSFORMER £1/6/- extra.

COMPLETE MULLARD 3-3

A VERY HIGH QUALITY AMPLIFIER DEVELOPED FROM THE VERY POPULAR 3-VALVE 3-WATT AMPLIFIER DESIGNED IN THE MULLARD LABORATORIES.

Price for COMPLETE KIT OF PARTS **£7.10.0**
(Plus 6/6 carriage and insurance).
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H.P. TERMS: Deposit £2 and 8 monthly payments of £1.

Our kit is complete to the MULLARD specification including supply of specified components, valves and PARMEKO OUTPUT TRANSFORMER. We also include switched inputs for 78 and L.P records plus a Radio position. Extra power to drive a Radio Tuning Unit is also available.

STEREO "3-3" MAIN AMPLIFIER

Comprises two MULLARD 3-3 Main Amplifiers on one chassis. Operates with MULLARD STEREO PRE-AMPLIFIER. Output power 6 watts. Inputs for Crystal Pick-up and Radio Turner.

KIT OF PARTS ..... **£10.0.0** or ASSEMBLED..... **£11.15.0**

Mk. II "Fidelity" FM TUNING UNIT

An attractively presented Unit incorporating MULLARD PERMEABILITY TUNING HEART and corresponding Mullard valve line-up. Very suitable to operate with our Mullard Amplifiers.

FOR THE CONSTRUCTOR .... **£10.10.0** or ASSEMBLED.... **£14.5.0**

SPECIAL CASH ONLY OFFER ! !

This very attractive PORTABLE AMPLIFIER CASE together with a good quality GRAM AMPLIFIER and a matched P.M. SPEAKER, ALL FOR ONLY (plus 7/6 carr. and ins.). The Amplifier consists of a 2-stage design incorporating the 3 modern BVA valves and has separate BASS and TREBLE CONTROLS. The Portable Case will also accommodate almost any make of Autochanger and is attractively finished in Grey Colour Rexine—WE ALSO SUPPLY SEPARATELY:— **£8.7.6**

a) The 2-stage (plus Rectifier) AMPLIFIER £4 2 6

(b) The PORTABLE CARRYING CASE £3 17 6

(c) 6½in. P.M. SPEAKER.... 18 9

(Carriage and Insurance 4/- extra)

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WE HAVE IN STOCK A COMPLETE RANGE BY GOODMANS—WHARFEDALE—W.B.
ILLUSTRATED AND PRICED LEAFLETS ON REQUEST

THE "ADD-A-DECK"

incorporating the NEW B.S.R.

"MONARDECK" & MATCHED PRE-AMPLIFIER
Thus providing full tape Recording facilities.

Carriage and Insurance 10/-.

Deposit £3/12/- 12 mths. £1/6/2 **£17.17.0**

Designed to operate through the Pick-up Sockets of the standard RADIO RECEIVER or Small Amplifier which first-class results are obtained. It consists of a Twin Track Tape Deck, incorporating matched Pre-amplifier, and operates at 3¾in./sec. speed. Supplied fully tested and only requires connections to the mains supply and the Pick-up Sockets, for which purposes "floating" leads are incorporated.

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Prices quoted are subject to £1/6/- extra for Partridge Trans.

MULLARD FOUR CHANNEL MIXING UNIT

Self powered wth Cathode follower output. Incorporates Two inputs for CRYSTAL MICRO PHONES, one for CRYSTAL PICK-UPS and a Fourth for Radio or Tape.

KIT OF PARTS **£8.8.0** ASSEMBLED AND TESTED **£10.0.0**

Terms Deposit £2 and 12 months at 15/-.

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Meets the many requests for a low priced but good quality Stereophonic Amplifier. Output power is 4 watts. Inputs for Crystal Pick-ups and Radio Tuner.

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This model incorporates two 2-valve Pre-Amplifiers (described above) combined into a Single Unit enabling it to be used for both STEREOPHONIC and MONAURAL operation. It is designed primarily to operate with our range of MULLARD MAIN AMPLIFIERS but will also operate equally well with any make of Amplifiers requiring an input of 250 m/v.

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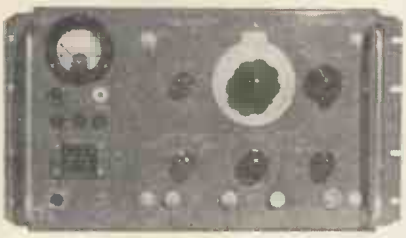

FEATURES

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Offered straight from Service use, complete with calibration book, cables, circuit diagram and principal technical information, checked serviceable and fully guaranteed **£17.10.0**

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Modern, portable, battery operated, 5 valve Signal Generator with alternative crystal or master oscillator, either optionally modulated by 1,000 c/s Hartley oscillator. Large directly calibrated dial with precision slow motion drive. Five step and variable attentuator. Supplied with matching black crackle carrying case for 6 and 135 volt batteries with 10ft. supply cable, and metal cased 1 mA. test meter for checking crystal resonance, etc. Brand new. £2/17/6 *plus* 7/6 *packing and carriage.*

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Self-contained, tunable-input, valve-voltmeter with telescopic aerial and battery-fed diode rectifier and pentode amplifier for measuring field strength, presence of modulation, and approximate frequency of transmitter. Compensating circuit for state of 1½ and 45 volt batteries. In attractive black crackle case. Brand new.

£2/5/- *plus* 5/- *packing and carriage.*

D.C. GYRO & SERVO MOTOR

Beautifully engineered Minneapolis-Honeywell precision gyro, totally enclosed in sealed light-alloy housing about 8½in. cube. Automatic erection and precession correction. Large diameter Dessyn type transmitting potentiometers provide signals corresponding to the magnitude of the deviation of gimbal arms. Powerful D.C. motor coupled through a differential reduction gear to a 4in. spur driving gear integral with a 3in. dia. spiral groove cable driving drum. Two powerful solenoid clutches and corresponding brakes hold drum rigidly in position or set free for "neutral." Nominally for 26-volt operation, but operates at 12 volts. Size 10 × 6 × 8in.

£10 each unit or £17/10/- pair, carriage paid.

£10 GEIGER COUNTER

Circuit embodes U.K.A.E.A. patent. Specially moulded case. Currently being supplied throughout the world. Three ranges—highly sensitive—light—portable—visual and audible response—plus output socket. Ideal for introduction to radiation measurement and nucleonic circuitry. Specially written 40-page instruction manual supplied. Batteries £2/15/3 extra.

KIT OF PARTS £4/17/6

Identical parts. Guaranteed performance. Manual and printed circuit plates for battery pack supplied (assembled pack £2/15/3 extra). Fully illustrated assembly instructions. Spares and service permanently available.

ROTARY RELAY.

Superb, fast acting, brand new precision unit made by Price for RCA. Nominally 12 volt, but mighty lively on 6-volt supply. Two heavy duty single pole changeover contacts and one low current for external circuits, plus one break set that extends coil winding to reduce initial energising current to 50 mA. (at 6 v.) for holding. Solid milled armature, laminated steel frame, 2¼ × 2½in. ⅜in. thick, moulded inset dielectric block.

A highly recommended spares box buy at 7/6 each, *post free.*

CHROMEL/ALUMEL THERMOCOUPLE LEADS

7, 10 and 21 foot lengths of flat twin lead—90% nickel, 10% chrome and 95% nickel, 5% aluminium. Total resistance 0.875 ohms. For use with millivoltmeter to read 0 to 1,000°C. Sheathed in heat resisting silicon rubber that will stand 200°C. Price, post paid, 7/6, 10/6 and 21/- respectively.

VARIABLE SPEED HYDRAULIC GEARBOX

This specially made oil-filled caseing houses a hydraulic torque conversion unit originally precision made by Westinghouse from high quality materials for the U.S. Government at an acquisition cost exceeding £150 each. Highly suitable for lathe head drive, workshop variable speed power take-off, etc.

Basically the unit is a back-to-back mounted, oil submerged, variable displacement hydraulic pump (input shaft) feeding a reversible hydraulic motor (output shaft) so that variation of the pump displacement by manual control gives very fine selection of output speed from zero up to 6% below input speed while a changeover valve in the supply lines to the motor provides instantaneous reverse at any speed. Recommended intput speed 500-1,000 r.p.m., maximum power 1½ h.p. Both shafts ⅝in. dia. with Woodruff key.

Tested and fully guaranteed, supplied complete with technical data and performance curves for the remarkable price of £16 only, carriage paid.

NOMOTRON DECADE COUNTER TUBES

STC Type G10/241 latest type cold cathode, gas-filled, single pulse, uni-directional decade counter which illuminates numerals on tube face. Operating range—20 kc/s. Cathode output 40 volts, 3.7 mA. HT supply 310 v. plus. Applications include: tachometers, counting and batching, frequency and time measurement, direct operation of electro-magnetic relays, sequential monitoring of up to 10 different waveforms, etc. Brand New, complete with special base and instructions. **32/6** post paid.

BC.929 SCOPE UNIT

Neat, modern indicator unit especially suitable for quick conversion to attractive general servicing scope. **(Suitable circuit diagram and all component values supplied.)** Contains fully mu-metal screened 3BP1 tube, intensity and focus controls, 3-position rotary switch and 8 pre-set, potentiometers, plus 2 × 6SH7, 2 × 6H6, 6G6, 6X5 and 2X2 valves. Designed for 24 v. D.C. or 400 c/s A.C. input. Size 14 × 8½in. square. Well known and deservedly popular buy. Offered new, less (unwanted) motor driven aerial switching unit, for post paid. **50/-**

200/220v D.C. to 200/250v. A.C. 50 c/s.

New 200-watt D.C. to A.C. rotary inverters in sound-proof cabinet. £9/10/- *carriage paid.*

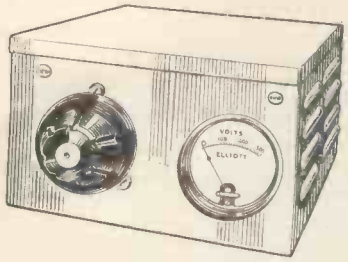
EVERETT EDGCUMBE SYNCLOCKS

Grade 1 industrial process timer with 3 inch dial covering ¾ to 10 minutes in one tenth divisions. Driven by a 16 volt 50 c/s synchronous clock. A metal rectifier provides D.C. to pull in a relay that engages the drive until the time set on the dial elapses. As it reaches zero heavy duty contacts snap shut to close the external circuit (at the same time other contacts break to arrest the clock). Switching off the power trips the relay and the spring loaded dial returns to the time set ready for the next cycle. Whole totally enclosed in a heavy cast wall mounting case, stove enamelled black, size 6½ × 7 × 4 inches. Brand new in original packings **55/-** post paid.

VENNER TIME SWITCHES

Type T.S.2, first grade precision time switches as supplied to G.P.O. Comprises absolutely silent self starting 250 volt 50 c/s synchronous clock, mechanism totally enclosed in heavy gauge brass case. Central drive takes detachable dial that revolves to operate sensitive on and off trips for external mains operated circuit. Self contained clock is easily detachable from rear mounting panel (self starting down to 80 v. and keeps running down to 15 v.).

Brand new, in original packings, and with dial and adjustable stops, post paid. **37/6**



BRAND NEW VARIABLE VOLTAGE TRANSFORMER. 230 volt A.C. input. Fitted in steel hammer finish case complete with 0–300 volt M.C. A.C. Meter, fuse and neon Indicator light. Output constantly variable from 0-270 volt A.C. Type 1. 2.2 amp. Price **£8/10/–**, carriage 10/–. Type 2. 5 amp. Price **£12**, carriage 10/–.

BRAND NEW VARIABLE VOLTAGE TRANSFORMER. For 230 volt A.C. input. In cases exactly as above with meter, fuse and indicator light. Output constantly variable from 0-230 volt A.C. Type 15. 15 amp. Price **£22/10/–**. Carr. 15/–.

W. W. RHEOSTAT. New. 3.5K or 5K. 25 watts. Price **7/6**. P. & P. 1/6.

NEW WIRE WOUND RHEOSTAT ON CERAMIC. 58 ohm. 50 watt, complete with instrument knob. Price **8/6**. P. & P. 1/6.

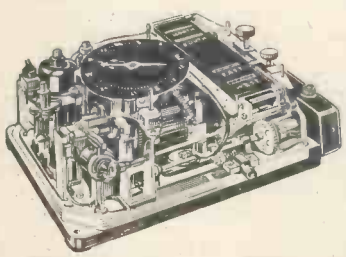
EX P.O. MAGNETIC COUNTER. 500 ohm type for 24 volt also 3 ohm type for 6 volt D.C. operation. Price **6/6** each. P. & P. 1/–.

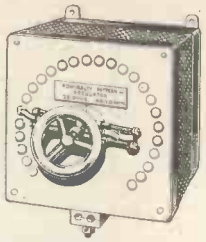
AUTO TRANSFORMERS. Step up, step down. 110–200–220–240 v. Fully shrouded. New. 300 watt type **£2/2/-** each. P. & P. 2/6. 500 watt type **£3/3/-** each. P. & P. 3/9. 1,000 watt type **£4/4/-** each. P. & P. 6/6.

HEAVY DUTY L.T. TRANSFORMER. Very conservatively rated for continuous duty. New. In manufacturer's cases. Input 110-260 volt multi-tapped. 50 cycles, single phase. Output 28–29–30–31 volts at 21 ampere. Price **£6/15/-**, carriage 10/–.

NEW GALVANOMETERS. Solid brass, 3in. dial, in polished wooden case. 70 degree scale, 35 mA either side. 100 ohm coil. Price **12/6** each. P. & P. 1/6.

EX R.A.F. AIR POSITION INDICATOR, containing 3 ball and plate infinitely variable resolving gears, miniature spur bevel and worm gear drives, also toggle, push button and rotary switches, repeater motor, 4 mechanical counters, miniature lamp holders and lamps etc. As new. Illustration below. **Price 22/6.** P. & P. 3/6.





ROTARY SWITCH REGULATOR. 25 ohms, very conservatively rated at 4 amp., will handle 8 amp. Overall size 7 x 8 x 6in. Price **15/-**. P. & P. 2/6.

EVERSHED AND VIGNOLES "WEE MEGGER." 500 volt in brand new leather case. Guaranteed perfect. Price **£13/15/-**. P. & P. 2/6.

A.R.B. U.S.A. RECEIVERS. 24 volt. Covering 195-9,050 k/c. in 4 bands. As new, suitable for use on boats, etc. Price **£6** including carriage.

HIGH SPEED RELAY. Siemens. Two bobbins 1,000 ohms each. New, **10/6** each. P. & P. 1/-.

18-WAY P.V.C. COVERED 14/36 WIRE, screened overall, covered with P.V.C., all colour coded, **3/6** per yd.; **£15** reel of 100 yds. Carriage paid.

BRAND NEW FREQUENCY METERS manufactured by Nalder & Thompson Ltd. Calibrated 45 cycles to 55 cycles per second. 6in. dial. Panel mounting type. In original manufacturer's boxes. PRICE £10/15/- ea. Postage 3/6.

20 WAY STRIP containing standard Post Office telephone Jack Sockets, overall size 11 x 3½ x ½in. New. Price **15/-** each. P. & P. 1/6.

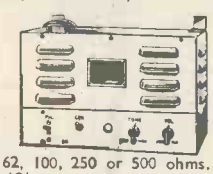
10 WAY STRIP standard Post Office telephone Jack Sockets, spacing allowing Igranic Jack Plugs. New. Price **10/-**. P. & P. 1/6.

19-INCH RACK MOUNTING 20-WAY P.O. JACK STRIPS with 40 terminals at rear. Price **25/-**. P. & P. 3/6.

19-INCH RACK MOUNTING 20-WAY P.O. LAMP STRIPS. Price **25/-**. P. & P. 2/6.

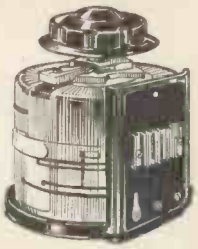
LATEST MOST MODERN TYPE OF EX W.D. MINIATURE HEADPHONES. As illustrated. Brand new, low impedance. Price: **10/6** plus P. & P. 1/6.

NEW MOVING COIL HEADSETS. Complete with Tannoy carbon hand microphone, with plug suitable for No. 19 set. Price: **12/6** each, plus P. & P. 2/-.

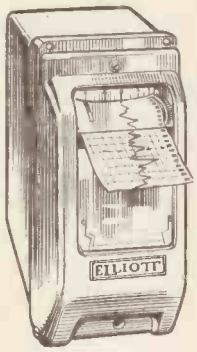


12 v. D.C. AMPLIFIER, as new, for operation on 12 v. car battery, 10 watts undistorted output, with 6L6 valves in push-pull. Mike/Gram. input, tapped output 7½, 15, 62, 100, 250 or 500 ohms. **£9/17/6** each. Carr. 15/–.

PYE LEVER OPERATING MICRO SWITCHES. Single pole change over. Brand new. 4/- each or 42/- dozen, p. paid.



VARIABLE VOLTAGE TRANSFORMER, "BERCO." Brand new in manufacturer's boxes. For 110 volt A.C. Input. Constantly variable from 0-135 volts. 2.2 amp. type. **£4**. P. & P. 3/–. 5 amp. type **£6/10/-**. P. & P. 3/6.



ELLIOTT SWITCHBOARD MOUNTING PEN RECORDER. 2¾in. chart. 1 mA. movement. 2 speed mechanism. Complete with pen, and charts. Reconditioned as new and guaranteed. Limited quantity. Price **£55**, carriage 10/–.

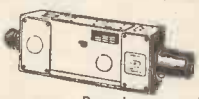
PLATE TRANSFORMER of very best U.S.A. make, brand new, original manufacturer's cases. Input tapped at 190/210/230/250 v. Output 2250-0-2250, centre tapped 400 mA. Nett weight 76lb., size 13in. x 9in. x 6½in. **Price £6/10/-** each, plus carr. 10/-.

NEW UNCHARGED UNFILLED 12 VOLT ACCUMULATOR 9 ampere in unspillable plastic cases. Comprises 6 x 2 v. separate cells connected by terminal strips. 6 x 5¼ x 4¼in. over terminals. Price **19/-**, plus P. & P. 2/9.

245 AMP. 2 VOLT ACCUMULATOR. Admiralty type in wooden casing. Size 15 x 7½ x 7½in. Weight 60lb. Unfilled, uncharged. New. Price £4. Carriage 10/–.

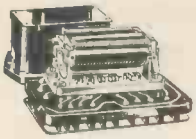
MINIATURE P.M. MOTOR. 12/24 volt, reversible. 1⅜in. dia. New. Price **10/6** each. P. & P. 1/–.

AIRCRAFT CINE CAMERA G45B Mk. III. Fully modified, fitted with f/3.5 triple anastigmatic lens, takes 25ft. of 16 mm. film, fitted with 24 v. motor. 16 exposures per sec. Brand new, original packing, **£4/10/-** each. P. & P. paid.



SERVICE TRADING COMPANY

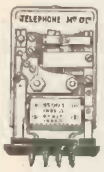
SLIDER RESISTANCES. 2 amp. 500 ohms, size 14in. x 6in., plus handle 6in., **27/6**. P. & P. 3/6.



SOLENOID OPERATED MAGNETIC RELAY. Type 5CW/3945, 4 pole changeover, 10 A contacts 24 v. operation. Brand new **13/6**. P. & P. 1/6.

CARPENTER'S TYPE POLARISED RELAYS. 2 x 9,500 turns at 1,685 ohms. Price **22/6** each. P. & P. 1/-.

Carpenter's similar to above, but type 5A48. Coils 1 x 3200 turns at 100 ohms and 1 x 2000 turns at 145 ohms, **22/6** each. P. & P. 1/- Bases for same 2/6.



SIEMENS H.S. RELAY. Very latest type, sealed. H96E. 1,700 ohms plus 1,700 ohms, single C.O. contacts. Brand new with fixing clip. In maker's cartons. Price **16/6** each, plus 1/- P. & P.

Siemens sealed similar relay to above, but 2.2 ohms plus 2.2 ohms. Minus clips, **12/6** each. Plus 1/- P. & P.

SUPERIOR BRAND NEW RELAY. 7,000 ohms coil. Will pull in at 750 microamp, and out at 450 microamp. Change-over, platinum contacts. Vacuum sealed, will therefore not be affected by oil, moisture or water and never needs adjusting. Weight 2½ oz. Price **18/6**. P. & P. 1/-.

MINIATURE MOVING COIL DIFFERENTIAL RELAY. Two coils 350 ohms each. Operating current minimum 140 microamp., nominal 400 microamp, maximum 8 milliamp. One pole two way, or, centre stable. Two way contact current 100 mA at 50 V. A.C. or D.C. Size 1¼ x ⅜ x ¾in. Price **22/6** each.

G.E.C. SEALED RELAY. Type M.1090. 180 ohms coil. 6/12 volt. 4 C/O. Brand new. **18/-**. P. & P. 1/-.

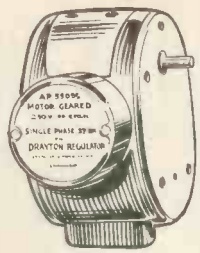
G.E.C. SEALED RELAY. Type M.1092. 670 ohms coil, 12/24 volt. 4 C/O. Ex new equipment. Unused. **10/-**. P. & P. 1/-.

G.P.O. 600 TYPE RELAY. 400 ohms coil. 24 volt. 2 C/O plus 2 M. New **7/6**. P. & P. 1/-.

MINIATURE OPEN TYPE RELAY. 700 ohms coil. 24 volt. 2 C/O. Ex new equipment. Unused. **7/6**. P. & P. 1/-.

ROTARY RELAY. 12 volt. Heavy duty change-over contacts and one low current for external circuit, plus one break set. Price **7/6**. P. & P. 1/6.

MINIATURE UNISELECTOR SWITCH. Two banks of ten plus home contacts one bank continuous of normal. 30 ohm coil for 24 volt operation. Brand new, manufacturer's packing. Price **22/6** each. P. & P. 2/6. As illustrated.

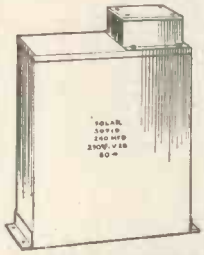


PRECISION MADE GEARED MOTOR BY DRAYTON REGULATOR CO., for 230 volt 50 cycles A.C.

TYPE R.Q.R., reversible. 37 r.p.m., overall size 5in. x 4in. x 5½in. Weight 4½ lb. Ex brand new equipment. Unused. Price **£3/17/6**. P. & P. 3/-.

SOLAR OIL-FILLED CONDENSER. 240 mfd. for 230 V.A.C. or 600 volt D.C.

Overall size 14in. x 9in. x 5½in. plus feet. Weight 46 lb. Brand new. Guaranteed perfect. Manufacturer's packing. Price **£7/10/-**, carriage 10/-.



DIAL THERMOMETER. Made by Short & Mason, Calibrated 0-160 degrees Fahrenheit. 4½in. dial. 6in. rim for flush mounting with 6in. long rod protruding at the back. Brand new. Manufacturer's packing. Price **22/6**. P. & P. 3/-.

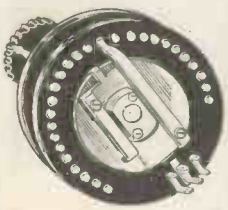
SPECIAL OFFER. LIMITED QUANTITY.

GENERAL PURPOSE CATHODE RAY OSCILLOSCOPE

The famous model 160-B C.R. 'Scope.. manufactured by R.C.A. of U.S.A. Best general purpose instrument of its kind, complete with 6in. cathode ray tube. Unused, guaranteed perfect. For operation on 110 v. A.C. Price **£22/10/-**. Carr. 10/-.

Step-down transformer to enable the above to operate on 230 v. Price **19/6**.

BRAND NEW SOUND POWER OPERATED EX-ADMIRALTY HEAD AND BREAST SETS. Two such sets connected up will provide perfect intercom., no batteries required. Will operate up to ½ mile. Original manufacturer's boxes. Price **17/6** each, plus P. & P. 2/-; or **32/6** per pair. P. & P. 3/-.



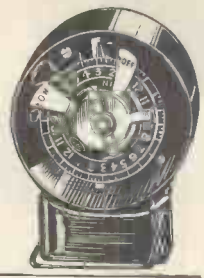
MUIRHEAD PRECISION, 1 bank, 1 pole, 25 position Stud Switch. Brand new. Price **12/6**. P. & P. 1/-.

MIDGET ROTARY TRANSFORMERS 2½in. dia. x 4½in. Input 11.5 volt. Output 310/365 volts at 30 mA. Brand new. **12/6** each. P. & P. 1/6.

MINIATURE INSTRUMENT RECTIFIERS. Bridge Type 1 milliamp. Guaranteed perfect, **7/6** each.

S.T.C. RECTIFIER. 36 plates by 120 mm. Bridge connected. Maximum A.C. input 60 volt, D.C. output 15 amp. New, perfect. Price **60/-**. P. & P. 3/6.

8-day clockwork Time Switch. Contacts 2½ amp., 230 volt, 24 hour phase, ¼ hour divisions, allow setting for one make and one break to be made every 24 hours, complete with key. Used but guaranteed perfect. Price **27/6** each. P. & P. 1/6.



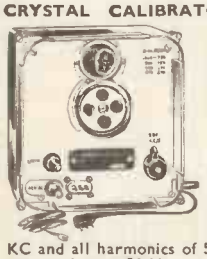
METERS GUARANTEED PERFECT

Charging Types	
2½ amp. D.C. M.I. 2in. fl. rnd.	7/6
5 amp. D.C. M.I. 2½in. fl. rnd.	11/6
7½ amp. D.C. M.I. 3½in. proj. rnd.	12/6
9 amp. D.C. Hot Wire W.R. 2½in. fl. rnd.	6/6
15 amp. D.C. M.C. 2in. rnd.	10/6
30 amp. D.C. M.C. 2in. fl. sq.	12/6
100 amp. A.C. M.I. 4½in. fl. rnd.	32/6
Voltmeters	
12 v. D.C. M.C. 2½In. proj. rnd.	8/6
20 v. D.C. M.C. 2in. fl. sq.	10/6
25 v. D.C. M.C. 2in. fl. rnd.	7/6
30 v. M.I. 3in. proj. rnd.	10/6
40 v. M.C. 2in. fl. sq.	10/6
300 v. A.C. M.C. 2½in. fl. rnd.	27/6
300 v. A.C. M.I. 2½in. fl. rnd.	22/-
400 v. A.C. M.I. 4½in. rnd.	35/-
Milliammeters	
1 mA. M.C. 2½in. fl. rnd.	25/-
200 mA. M.C. 2½in. fl. rnd.	12/6
500 mA. M.C. 2½in. fl. rnd.	12/6
Microamp	
50 microamp., scaled 0-100, M.C. 2½in. fl. rnd.	42/6
50 microA. 2½in. square, side fitting scales	35/-
500 microamp., M.C. 2in. rnd. F.L. scaled 15/600 volt. NEW	16/6

Postage on all meters 1/- each.

Miniature latest type moving coil 0-5 milliamp meter, 1½in. diameter, flush fitting, complete with fixing clip. Price **17/6**. P. & P. 1/-.

CRYSTAL CALIBRATOR No. 10. A crystal controlled 4-valve high-grade instrument in the same category as the famous B.C. 221. Directly calibrated, does not require cross reference or charts — functions as follows: (1) A crystal controlled oscillator which provides fixed frequency signals of 500 KC and all harmonics of 500 KC to beyond 10 Meg. and up to 30 Meg.



(2) A variable oscillator from 250 KC to 500 KC, this enables all intermediate frequencies between 250 Kc/s. and 30 Meg. to be produced and modulated.

Supplied complete with 3 spare valves, all leads and maker's instruction book in carrying haversack. The complete outfit is brand new—repeat NEW. Price: **£4/19/6**. Carr. 3/-.

TWELVE PLATE F.W. BRIDGE CONNECTED RECTIFIER mounted on 200/250 volt A.C. input transformer. Output 36/40 volt D.C. at 1.2 amps. New, perfect. Price **16/6**. P. & P. 3/6.

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THE EASY SIX

6-Transistor Battery Portable

MAY BE BUILT FOR £9.15.0 plus 3/- p.p.

Ever Ready PP7 Battery Extra 3/3

STAR FEATURES: ★ Six 1st grade Mullard Transistors ★ Internal Ferrite Rod Aerial ★ Provision for Car Radio Aerial ★ 5in. Loudspeaker ★ Printed circuit, with component positions indicated ★ Preassembled Dial Assembly ★ 500 milliwatts Push Pull output ★ Full medium and long waveband coverage ★ Attractive two-tone Blue/Cream Vynide covered Cabinet, dimensions 8½in. x 6½in. x 3in. ★ Full point-to-point instructions supplied. ★ Weight 3lb. with battery.

Assemble it yourself and SAVE £ £ £'s

COMPACT GRAM. AMPLIFIER

2-valve printed circuit type for use on A.C. or D.C. 200/250 v. mains incorporating modern miniature valves. Output 2 watts, overall dimensions 6½ x 2 x 3½in.

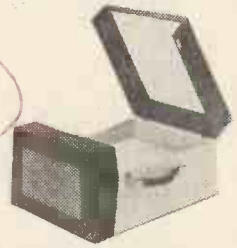
Price 59/6, plus P. & P. 2/6.

Amplifier Cabinet, £2/19/6, plus 5/- P. & P.

7 x 4in. Elliptical Speaker, £1/1/6, plus 1/6 P. & P.

Latest-type Collaro Conquest 4-spd. Changer £7/19/6, plus 5/- P. & P.

If all the above items are purchased at the same time they can be supplied at £13/15/-, plus 10/- P. & P.



TAKE ADVANTAGE OF THESE

DRAMATIC PRICE REDUCTIONS

AVANTIC DL7/35 Power Amplifier. Specifications: power output 54 watts peak; L.S. impedance 4, 8 or 16 ohms, power inputs 10S-2S0 v. Valve line-up GZ34, 2-EL34, ECC83, EF86. Dimensions 14½ x 9 x 8½in. Original price 30 gns. P. & P. 12/6. **OUR PRICE £16/19/6.**

AVANTIC SP21. Stereophonic Pre-amp. Control Unit. Brief specifications, 6 inputs for each channel, bass, treble, volume control, on/off stereo/3D/reverse stereo switch, stereo phase switch, low pass filter. Power requirements 6.3 v. at 1.3 A., A.C. 350 v. at 5 mA. D.C. Dimensions 14½ x 9 x 4in. Original price £28/10/-. P. & P. 7/6. **OUR PRICE £16/19/6.**

AVANTIC SPA11 Stereophonic Amplifier. Technical details: power output (each channel) 10 watts peak, L.S. impedance, 4, 8 and 16 ohms 6-position input selector, bass, treble, volume on/off controls, stereo reverse switch, phase reverse switch, stereo balance control, P.U. balance control. Dimensions 14½ x 8¾ x 4in. Original price 28 Gns. P. & P. 7/6. **OUR PRICE 19 Gns.**

AVANTIC PL621 20-watt monaural Amplifier, frequency response 10 c/s-30 Kc/s. 1dB. L.S. impedance 4, 8 or 16 ohms. Dimensions 14in. x 8½in. x 7½in. Original price 29 Gns. P. & P. 7/6. **OUR PRICE 19 Gns.**

AVANTIC STEP II. Stereophonic Magnetic Pick-up Amplifier Unit. Price £4/4/-.

All this equipment is Brand New and in manufacturer's original sealed cartons. Full descriptive literature available.

THE Petite PORTABLE

MAY BE BUILT FOR £7.7.0 p. & p. 3/-

Batteries extra.

H.T. 10/- (Type B126) or equivalent.

L.T. 1.6 (Type AD 35, or equivalent.

- High Q frame aerials.
- High sensitivity on both wavebands.
- Medium and long wave superhet circuit.
- Instruction book 1.6.
- Size only 8 x 8 x 4½in.
- Weight including batteries 5½lb.
- 4 valves of the economy type.

WHY NOT TAKE ADVANTAGE OF THIS WONDERFUL OFFER!

Two DL7/35 POWER AMPLIFIERS combined Price

SP21/2 STEREO CONTROL UNIT 47 Gns.

THE MODEL FMA/1 FERGUSON FM TUNER

13 gns plus 3/- p. & p.

For use with Radio Receivers or Hi-Fi equipment. Completely self-contained, self-powered and housed in a hammered metal finished steel case, 10 x 7½ x 2½in. Frequency coverage 87.6-100 Mc/s. (continuously). Valve line-up: 2—EF80, ECF80, 2 germanium diodes and metal rectifier, for operation on A.C. mains 200/250 v. 50-60 cycles.

PREMIER BATTERY ELIMINATOR

Housed in two containers which are to replace AD 35 and B126 batteries.

KIT 37/6 plus 2/- post and packing. *Only suitable for use with DK 96 Series valves.*

TUNERS FOR THE HOME CONSTRUCTOR BY 'JASON'

JASON JTV2. T.V. SOUND & F.M. complete with Turret Tuner and Case less Valves, £14/19/0, plus 3/6 p. & p. Valves £1/12/0. Instruction Book available separately 3/6d.

JASON FMT3. F.M. Tuner with Twin Limiters, sensitivity 5 microvolts, complete with Case and Power Supply, £9/19/0 Less Valves, plus 3/6d. p. & p. Valves £2/13/0. Instruction Book available separately 2/6d.

JASON MERCURY 2. Switched Tuner for F.M. and T.V. Sound, less Valves and Power Supply, £10/14/0, plus 2/6d. p. & p. Valves £1/4/6. Instruction Book available separately 3/6d.

Power Supply Kit, suitable for above £2/14/0, plus 2/- p. & p.

WHY NOT DO IT YOURSELF!

SUPERHET may be built for £7 . 7 . 0 Plus 3/- p. & p.

T.R.F. may be built for £5 . 10 . 0 Plus 3/- p. & p.

These two receivers use the latest type circuitry and are fitted into attractive cabinets 12 x 6½ x 5½in., in either walnut or ivory Bakelite or wood 1/- extra. Individual instruction books 1/- each, post free.

THE 'CLARION'

Transistorised miniature battery-operated

TAPE RECORDER

★ Completely transistorised circuit.

★ Constant governed speed of 3¾ I.P.S.

★ Recordings interchangeable with other recorders.

★ Remarkable reproduction on both speech and music.

Price complete with Microphone and tape— **25 GNS.** plus 5/- P. & P.

THE 'MID-FI'

A NEW DESIGN 4½ WATT AMPLIFIER KIT

MAY BE BUILT FOR 95/-

Plus 3/- p. & p.

A new circuit for the home constructor requiring a good quality medium-powered Amplifier for reproduction of Records or F.M. Broadcasts. Technical Specifications: separate bass and treble controls. Valve line-up EF86, EL84, E280. Voltage adjustment for A.C. mains from 200/250 volt, 3 or 15 ohms impedance. Negative feedback. Size 7 x 5 x 2in., overall height 5in. Silver-hammered finished Chassis.

THE VICEROY QUALITY CRYSTAL MICROPHONE

A good-quality crystal Microphone for the discerning enthusiast, finished in polished steel with Muting Switch and detachable lead. Price 42/-, P.P. 1/6.

FOR THE BEGINNER

A three-transistor, medium wave, receiver, ideally suited for the young enthusiast or the beginner. Incorporating two transistors and one diode and operating on two pen torch batteries.

Simple to construct, with full instructions supplied. No headphones required.

Complete set of components, including plastic case, **27/6** plus 1/6 P. & P. Batteries extra.

THE MODEL VT41 VALVE FILAMENT TESTER

Will instantly check the filaments of all Radio and T.V. Valves, Fuses and Dial Bulbs. Will also give an accurate circuit continuity test and also has built-in 7 and 9 valve straighteners. Size 5¾ x 3¾ x 1¾in.

PRICE 30/- with Battery, post paid.

CABY MODEL B20 MULTI-METER

DC/V 0-0.5 v. 0-2.5 v. (2K.ohms/V)

DC/V 10-50-250-500-1000 v. (4K·ohms/V).

AC/V 10-50-250-1000 v. (4K.ohms/V).

DC/mA 0-100 microamps (500mV).

DC/mA 0-2.5-25-250mA (250mV)

OHMS, 2K·20 meg.

COMPLETE WITH TEST LEADS—

PRICE **£6/10/0** plus 2/- P. & P.

CABY MULTI-METER A-10

DC/V 10-50-250-500 1kΩ (2kΩ/V)

AC/V 10-50-250-500-1kΩ (2kΩ/V)

Ranges: DC/mA 0.5-25-250 (250mV)

OHM 0-10 kΩ-1MΩ.

Complete with test leads P. & P. 2/6. **£4/17/6**

PREMIER RADIO

309 Edgware Rd., London. W.2. Tel: PADington 6963

Visit our large and comprehensive HI-FI showrooms

PRICE including Microphone, Tape and Spare Spool, **19 Gns.** Plus 15/- P. & P.

First Again!!

"THE PREMIER TR/2"

Once again, Premier is first, with another magnificent offer. Introducing the 'TR/2" the latest and cheapest addition to our range of popular Recorders.

Star features:

★Latest BSR Tape Deck, with interlocking device to prevent accidental erasure.
★Single speed 3¾in. per sec.
★Playing time 5¾in. std tape—1¾ hours. L.P. tape—2 hrs. 8 mins.
★Volume on/off and tone control.
★Power output 3 watts.
★Input sockets for Microphone, Radio/Gram.
★Extension speaker socket.

Size: 13½ x 9½ x 6in., weight 17 lb.

The 'Magnaphon'

A truly top quality and versatile Tape Recorder at a price well below the original cost. Incorporating the latest Collaro 3-speed Studio Tape Deck.

★ Volume and Tone Control for recordings.
★ Volume and separate Bass and Treble Controls for replay.
★ Facilities for monitoring.
★ Output 4 watts.
★ Separate Output Sockets for Amplifier and Extension Speaker.
★ Mixing Facilities.
★ Housed in attractive red and beige two-tone Cabinet with detachable lid.
★ Fully guaranteed and supplied complete with the following accessories:—

Price £32.0.0 Plus 21/- P. & P.

Good quality Crystal Microphone with Lead and Jack Plug fitted, 5¾" Reel of Standard Tape and Spare Reel spare Lead fitted with Jack Plug and Wander Plugs for recording from Radio.

TAPE DECKS

LATEST BSR MONARDECK. Single speed 3¾ l.p.s. Will take 5¾in. spools. £8/19/6. P. & P. 5/-.

COLLARO STUDIO TAPE TRANSCRIPTOR. 3 speeds 1¾, 3¾, 7½ l.p.s. 3 motors. Push-button controls. Will take 7in. spools. £12/19/6. P. & P. 7/6.

COLLARO MK. 4 TAPE TRANSCRIPTOR. Twin track operation, 3 speeds, 3¾, 7½, 15 l.p.s. Will take 7in. spools. £17/19/6. P. & P. 7/6.

TAPE RECORDER AMPLIFIER. specially designed to match the Collaro Studio Tape Deck. £10/19/6. P. & P. 4/-. Size 11¾ x 5 x 3in., uses 3 valves, magic eye, contact cooled metal rectifier. Incorporates mike/gram/radio inputs, ext. l.s. jack, superimposing switch with matching knobs.

RECORDING TAPE

By well-known manufacturers, brand new, boxed and fully guaranteed.

1,800ft. on 7in. spool	32/6
1,200ft. on 5¾in. spool	22/6

P. & P. 1/- per spool.

AMERICAN C.B.S. RECORDING TAPE

Brand new, fully guaranteed and with Leader Tape:—

600ft. on 5in. Spool	17/6
1,200ft. on 5¾in. Spool	25/-
1,800ft. on 5¾in. Spool D.P.	47/-
1,200ft. on 7in. Spool	25/-
1,800ft. on 7in. Spool L.P.	35/-

Plus 1/- per Spool. P. & P.

SINGLE PLAYERS

Collaro Junior 4-speed Player complete with Pick-up	£3 15 0
Garrard 4SP 4-speed Player, complete with Pick-up and automatic stop	£6 19 6
Garrard TA Mk. 2 4-speed Player, wired for stereo, with plug-in Head	£8 10 0
Philips AG2009 4-speed Player, with diecast turntable and Microlift, wired for stereo	£10 10 0

P. & P. 3/6 on above units.

RECORD CHANGERS

BSR UA3, 4-speed	£6 19 6
BSR UA8 4-speed with stereo cartridge	£7 19 6
BSR UA12, 4-speed, wired for stereo and complete with Stereo cartridge	£8 19 6
Collaro Conquest, 4-speed Changer	£7 19 6
Collaro RC457, latest type 4-speed changer	£8 10 0
Garrard RC111 3-speed Changer	£7 19 6
Garrard RC120 Mk. 2, 4-speed	£8 19 6
Garrard RC121/4D, 4-speed	£9 19 6
Garrard RC121 Mk. 2, 4-speed, wired for stereo and with plug-in Head	£10 19 6

P. & P. 5/- on above units.

TRANSCRIPTION UNITS

Garrard 301	£22 7 3
Garrard 301 (Strobe turntable)	£23 18 4
Garrard 4HF (Stereo)	£19 4 8
Garrard 4HF (GC3)	£18 9 9

P. & P. 7/6 on above units.

STEREO ADAPTOR

Why not convert your Record Player or Radiogram to stereo with this easy to install Stereo Conversion Unit, complete and ready to install giving an output of 3 watts.

STEREOPHONIC PICK-UP CARTRIDGES AVAILABLE, 35/- post paid.

PRICE £2.19.6 Plus 2/- P. & P.

The 'Vogue'

A quality tape recorder, at a popular price including microphone, tape and spare spool.

Price 29 gns. Plus 21/- P. & P.

★ Collaro 3-speed Tape Deck.
★ Separate Input for Microphone and Gram Recording.
★ Separate Volume Controls for recording.
★ Volume On/Off and Tone Control for replay.
★ 3 watts output.
★ Housed in smart two-tone Blue/Beige Cabinet with detachable Lid.

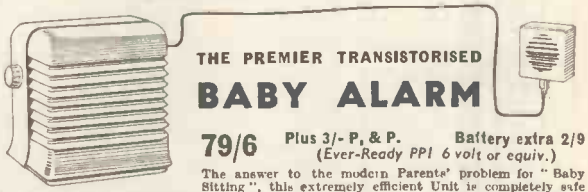
TAPE RECORDER RADIO JACK

May be built for 29/6 plus 1/6 p. and p. Tape Recorder Plug Extra.

Improve the quality of your recordings with the most inexpensive Radio Jack available, suitable for any type of Tape Recorder, only a short external Aerial required for full medium waveband coverage. Phono Plugs—9d., Jack Plugs—3/-.

INSTANT BULK TAPE ERASURE

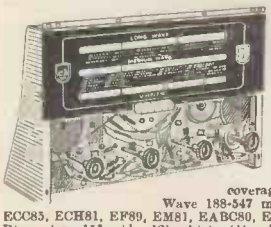
Erase complete Reels of Tape in a matter of seconds. PRICE 27/6 post paid.



THE PREMIER TRANSISTORISED BABY ALARM

79/6 Plus 3/- P. & P. Battery extra 2/9 (*Ever-Ready PP1 6 volt or equiv.*)

The answer to the modern Parents' problem for "Baby Sitting", this extremely efficient Unit is completely safe being battery operated, its portability enables you to place the Master Unit in any part of the house. Extra Microphones may be used in different rooms without impairing the efficiency of the Unit. It is the most economical Unit of its kind and will run on one Battery for approximately two months of continuous day and night use. It is housed in an attractive bakelite Cabinet in either ivory or pastel blue. The price includes one Microphone, extra Microphones can be supplied at 12/6 and Microphone Lead at 5d. per yard.



MODEL 379 AM/FM RADIOGRAM CHASSIS BY FAMOUS MANUFACTURER

PRICE £12.12.0 plus 7/6 p. & p.

Due to a fortunate bulk purchase we are able to offer these exceptionally good quality Radiogram Chassis at this ridiculously low figure. Gram./on/off Star features of this Chassis are: piano key wavechange Internal Ferrite Rod Aerial for AM and Magic Eye Tuning Indicator waveband coverage: Long Wave 1098-2027 metres. Medium Wave 188-547 metres VHF/FM 87-101 Mc/s. Valve line-up: ECC85, ECH81, EF89, EM81, EABC80, EL84, suitable for use on 200/250 v. A.C. mains. Dimensions 15¾ wide, 12in. high, 4¼in. deep.

3-WAVEBAND RADIOGRAM CHASSIS

By Famous Manufacturer

£10.19.6 plus 5/- p. & p.

A special offer for a limited period only of this Continental style Radiogram chassis.

Brief details: Long, Medium and Short wavebands covering 1007-1960 metres, 185-555 metres, 16-32 metres. Valve line-up: ECH81, EBF80, ECL82. Mains voltage 200/250 v. A.C. Gramophone Pick-up Input Dimensions 17¼in long, 5in. high 6in. deep

R.S.C. HI-FI TAPE RECORDER KIT

OR DEPOSIT £5/7/6 and 12 monthly payments of 42/-. Cash price if settled in 3 months.

Build a high quality recorder in the £70 class for only **25½ GNS.** Carr. 17/6.

Can be assembled in ½ hour.

INCORPORATING THE LATEST COLLARO STUDIO TAPE TRANSCRIPTOR' THE LINEAR LT45X HIGH QUALITY TAPE AMPLIFIER. A HIGH FLUX 7×4in. LOUDSPEAKER, Reel of Best Quality TAPE, Spare Tape Spool, a Portable Cabinet, size approx. 16 × 13 × 9in., finished in durable and attractive duo-tone Polierome. and connection diagram for wiring amplifier to transcriptor.

FEATURES INCLUDE

★ 3 SPEEDS ★ FREQUENCY RESPONSE 50-11,000 c.p.s. ★ SWITCHED NEGATIVE FEEDBACK EQUALIZING FOR EACH SPEED. ★ OUTPUT 4 WATTS ★ MAGIC EYE RECORDING LEVEL INDICATOR ★ 3 MOTORS. Fast rewind. ★ TAPE MEASURING AND CALIBRATING DEVICE. ★ TAKES FULL 7in. DIAMETER REELS OF TAPE. ★ NEGLIGIBLE HUM. ★ ENTIRELY EFFECTIVE AUTOMATIC ERASURE.

Full descriptive leaflet supplied on receipt of S.A.E.

HI-FI 10 WATT AMPLIFIERS

BRAND NEW CARTONED MANUFACTURERS DISCONTINUED MODEL. **£6.19.9** Carr. 7/6.

A REMARKABLE OPPORTUNITY

Push-pull output. Latest high efficiency Mullard valves Dual separately controlled inputs, for mike and gram. Separate bass and treble controls. High sensitivity. Output for 3 ohm or 15 ohm loudspeaker. Guaranteed, tested and in perfect working order. Please state speaker matching required when ordering.

SUPERHET RADIO FEEDER UNIT

Design of a high quality Radio Tuner Unit (specially suitable for use with any of our Amplifiers). A Triode Heptode F/changer is used. Pentode I.F. and double Diode Second Detector, delayed A.V.C. is arranged so that A.V.C. distortion is avoided. The W. Ch. Sw. incorporates Gram-position. Controls are Tuning, W. Ch. and Vol. Output will load most Amplifiers requiring 500 mV. input depending on Ae location. Only 250 v. 15 mA. H.T. and L.T. of 6.3 v. 1 amp. required from amplifier. Size of unit approx. 9-6-7in. high. Send S.A.E. for illustrated leaflet. Total building cost is £4/15/-. Point-to-Point wiring diagrams and instructions 2/6.

R.S.C. JUNIOR TAPE RECORDER KIT. Incorporates B.S.R. Monardeck Tapedeck, as used by most leading manufacturers of Recorders, our TR1 3 watt amplifier ready wired provides excellent quality at up to rated output, portable cabinet, 5in. reel Scotch tape, empty spool, and 6in. x 4in. speaker. Carr. 15/-. **17½ Gns.**

RE-ENTRANT LOUDSPEAKERS

For factory or outdoor use.

Tannoy 7.5 ohms 8 watts 25/9.

Parmeko horn type, highly efficient. Handles up to 10 watts. 15 ohm 200 ohm and 600 ohm matching 59/6. R.C.A. 20 watt rating, 3 ohm, 15 ohm. and 200 ohm 600 ohm matching 6 gns.

ACOS HI-FI CRYSTAL 'MIKES'

Mic 30 hand or Desk type **27/9** (Listed 45/-)

39-1 Stick type **39/6** (Listed 5 Gns.)

Limited number.

R.S.C. BATTERY TO MAINS CONVERSION UNITS

Type BM1. An all-dry battery eliminator, Size 5½ × 4½ × 2in. approx. Completely replaces batteries supply 1.4 v. and 90 v. where A.C. mains 200-250 v. 50 c/s. is available. Suitable for all battery portable receivers requiring 1.4 v. and 90 v. This includes latest low consumption types. Complete kit with diagram 39/9 or ready for use 46/9.

Type BM2. Size 8×5½×2½in. Supplies 120 v. 90 v. and 60 v., 40 mA. and 2 v. 0.4 a. to 1 amp., fully smoothed. THEREBY COMPLETELY REPLACING BOTH H.T. BATTERIES AND H.T. 2 v. ACCUMULATORS when connected to A.C. mains supply 200-250 v. 50 c/s. SUITABLE FOR ALL BATTERY RECEIVERS normally using 2 v. accumulator

Complete kit with diagrams and instructions. 49/9 or ready for use 59/6.

VALVES! Full range at really competitive prices.

THE SKY FOUR T.R.F. RECEIVER

A design of a 3 valve 200-250 v. A.C. mains L. and M. wave T.R.F. receiver with selenium rectifier. For inclusion in cabinet illustrated or walnut veneered type. It employs valves 6K7, 8P61, 6P6 and is specially designed for simplicity in wiring. Sensitivity and quality are well up to standard. Point-to-Point wiring diagram, instructions and parts list 1/9. This receiver can be built for a maximum of £4/19/6 including cabinet. Available in brown or cream bakelite or veneered walnut.

EXTENSION SPEAKERS. Handsome walnut veneered cabinets. All standard 2-3 ohms. 6½in. 29/9; 8in. 35/9.

R.S.C. A12 STEREO AMPLIFIER KIT

A complete kit of parts to construct a good quality 3 + 3 watt (total 6 watt) stereo amplifier providing really life-like reproduction. Suitable for use with all stereo pick-up heads at present available. Ganged volume and tone controls. Preset balance control. Outputs for matched 2 3 ohm speakers. For 200-250 v. A.C. mains. Astonishing value. **4 GNS.** Carr. and packing 7/6.

R.S.C. STEREO/TEN HIGH QUALITY AMPLIFIER KIT

Valves EZ81, ECC83, ECC83, EL84, EL84. Separate Bass and treble controls, giving "cut" and "boost." Sensitivity 50 mV. 5 watts high quality output on each channel. Can be used as straight 10 watt amplifier. Controls: Stereo/Monaural switch, ganged volume, ganged treble. ganged bass, and balance. Outputs for 3 ohm speakers. Point-to-Point wiring diagrams and instructions. Carr. 7/9. **8 Gns.**

Illustration full constructional details and priced parts list 1/9.

SELENIUM RECTIFIERS

We can quote special prices for quantities of 12 to 10,000 of most types. Special types made to order.

L.T. Types		H.T. Types H.W.	
2/6 v. ½ a. h.w.	1/9	120 v. 40 mA.	3/9
6/12 v. 1 a. h.w. ..	2/9	250 v. 50 mA.	3/11
Following F.W. (Bridge)		250 v. 60 mA.	4/11
6/12 v. 1 a.	3/11	250 v. 80 mA.	6/11
6/12 v. 2 a.	6/11	250 v. 250 mA.	12/9
6/12 v. 3 a.	9/9		
6/12 v. 4 a.	12/3	Contact Cooled	
6/12 v. 5 a.	14/6	250 v. 80 mA.	6/11
6/12 v. 6 a.	15/6	250 v. 75 mA.	10/11
6/12 v. 10 a.	25/9	F.W. (Bridge)	
6/12 v. 15 a.	35/9		

JUNCTION TRANSISTORS. R.F. Type 11/6. Audio type, 5/9. Power type Goltop V15/10P 2 watts, 17/9. OC71 10/-. OC72 16/9. XB102 10/-. XB104 10/-. XA101, XC101, OC44 17/6. XA102, XA103, XA104 12/9 and many other types.

RECORDING HEADS. Baird Record Playback and Erase-(housed in one container) 9/6 pair.

SPECIAL OFFER. of R.C.A. replacement stylii for Collaro Studio "C" and "P" Ronette and other pick-up heads. Sapphire type standard of L.P. 3/11 each. Diamond type normally 83/5. Only 29/11.

HEAVY DUTY CHARGER KIT

6/12 v. variable charge rate up to 6 amps. Consisting of Mains Trans., F.W. (Bridge) Selenium Rectifier, 0-7 amp. meter, multi-position switch with knob, fuses, fuse-holders, panels, plugs, and circuit. Only 59/6. Post 4/6.

Battery Chargers and Kits for 200-230-250 v. 50 c/s. A/C. Mains

ASSEMBLED CHARGERS

6 v. 1 a.	19/9
6 v. 2 a.	29/9
6/12 v. 1 a.	29/9
6/12 v. 2 a.	38/9

Above ready for use with mains and output leads. Cases well ventilated and finished in stoved blue hammer. Carr. & Pkg. 3/6.

CHARGER TRANSFORMERS

200-230-250 v. 50 c/s.

0-9-15 v. 1½ a.	12/9
0-9-15 v. 2½ a.	15/9
0-9-15 v. 3 a. ...	16/9
0-9-15 v. 5 a. ...	19/9
0-9-15 v. 6 a. ...	23/9

BATTERY CHARGER KITS

Consisting of Mains Transformer, F.W. Bridge, Metal Rectifier, well ventilated steel case. Fuses, fuse-holders, grommets, panels and circuit. Carr. 2/9 extra.

6 v. or 12 v. 1 amp.	24/9
As above, with ammeter...	32/9
6 v. 2 amps.	25/9
6 v. or 12 v. 2 amps.	31/6
6 v. or 12 v. 2 amps. ..... (inclusive of ammeter)	42/9
6 v. or 12 v. 4 amps.	53/9
6 v. or 12 v. 4 amps. with variable charge rate selector and ammeter	59/9

CHARGER AMMETERS

0-1.5 amp., 0-3 amp., 0-4 amp., 0-7 amp., 0-25 amp., 0-60 amp. 8/9

ASSEMBLED CHARGER

6 v. or 12 v. 2 amps. Fitted Ammeter and selector plug for 6 v. or 12 v. Louvred metal case, finished attractive hammer blue. Ready for use with mains and output leads. Double Fused. Only **49/9** Carr. 3/9.

As above, but for 3 amp. charging. Only 59/6. Carr. 3/9

ASSEMBLED 6 v. or 12 v. 4 amps.

Fitted Ammeter and variable charge selector. Also selector plug for 6 v. or 12 v. charging Double fused. Well ventilated steel case with blue hammer finish. Ready for use with mains and output leads. Carr. 5/-. Or Deposit 13/3 and 5 monthly payments of 13/3. **69/9**

As above, but for 6 amp. charging 4 GNS. Carr. 5/-. Or Deposit 16/- and 5 monthly payments of 16/-. The 6 amp. model only is slightly store soiled and is being offered at well below usual price

LINEAR L45 MINIATURE 4/5 W. QUALITY AMPLIFIER. Suitable for use with any record playing unit and most microphones. Negative feedback 12 D.B. Bass and Treble controls. For A.C. mains input of 200-250 v. 50 c.p.s. Output for 2/3 ohm speaker. Three miniature Mullard valves. Size only 6×5×5½in. high. Chassis fully isolated from mains. Guaranteed 12 months. Only Deposit 22/- and 5 monthly payments of 22/-. **£5.19.6** Or Send S.A.E. for leaflet.

W.B. "STENTORIAN" HIGH FIDELITY P.M. SPEAKERS

HF1012, 10 watts, 15 ohm (or 3 ohm) speech coil. Where a really good quality speaker at a low price is required, we highly recommend this unit with an amazing performance. £4/10/9. Please state whether 3 ohm or 15 ohm required.

D.C. SUPPLY KITS. Suitable for electric trains. Consist of mains trans. 200-250 v. 50 c.p.s.: 12 v. 1 amp. selenium rect. (F.W. Bridge); 2 fuseholders, 2 fuses, change direction switch, variable speed regulator, partially drilled steel case and circuit. Very limited number, 33/9.

REPANCO TWINETTE TRANSISTOR PORTABLE RADIO DESIGN. Constructional Envelope and parts list 1/3. Built-in Ferrite Aerial, 7in. × 4in. speaker, Long and Medium waves. Size approx. 7×4×3in. Total cost of all parts 5 gns.

LINEAR TAPE PRE-AMPLIFIER Type TP/1. Switched negative feedback equalisation. Positions for Record 1½in., 3½in., 7½in. and Playback. EM84. Recording level indicator. Designed primarily as the link between Collaro Tape Transcriptor and high fidelity amplifier but suitable almost any Tape Deck. **8 Gns.**

POWER PACK KITS. Only 18/11. Fully smoothed H.T. output of 250 v. 60 ma. and L.T. supply of 6.3 v. 1.5 amp. Consisting of Double Wound Mains Transformer 230/250 v. 50 c.p.s. A.C. primary. Selenium Rectifier, Smoothing Choke, Double Electrolytic Condenser. Aluminium Chassis and Circuit.

P.M. SPEAKERS. 2-3 ohms 2½in. Perdio 21/9. 5in. Goodmans 17/9. 7 × 4in. R.A. Elliptical 19/9. 6½in. Rola 19/9. 8in. Rola 19/9. 8in. Goodmans 25/9. 8 × 6in. Elac. with high flux magnet 25/9. 10in. R.A. 28/9. 10 × 6in. Elliptical Goodmans 29/9. 12in. R.A. 29/11. 12in. T.A. 3 or 15 ohms. 10 watts, 12,000 lines, 59/6.

TWEETERS. 4in. Plessey, 3 ohms, 18/9. R.A. 15 ohms 25/9.

R.S.C. A10 ULTRA LINEAR 30 WATT AMPLIFIER

HIGH FIDELITY PUSH-PULL UNIT EMPLOYING SIX VALVES. EF86, EF86, ECC38, 807, 807, GZ34. Tone Control Pre-Amp. stages are nicorporated. Sensitivity is extremely high. Only 12 millivolt minimum input is required for full output. **THIS ENSURES THE SUITABILITY OF ANY TYPE OR MAKE OR MICROPHONE OR PICK-UP.** Separate Bass and Treble controls give both "lift" and "cut" with ample tone correction for long playing records. An extra input with associated vol. control is provided so that two separate inputs such as "mike" and gram., etc., can be simultaneously applied for mixing purposes. **AN OUTPUT SOCKET WITH PLUG IS INCLUDED FOR SUPPLY OF 300 v. 20 mA. and 6.3 v. 1.5 A. FOR A RADIO FEEDER UNIT.** Price in kit form with easy-to-follow wiring diagrams. ONLY **11 Gns.** Or Factory built with 12 months' guarantee **£13/19/6.** TERMS ON ASSEMBLED UNITS. DEPOSIT 31/9 and 9 monthly payments of 31/9. Carr. 10/-.

Cover as illustrated 18/9 extra. Type 807 output valves are used with High Quality Sectionally wound output transformer specially designed for Ultra Linear operation. Negative feedback of 20 D.B. in main loop. **CERTIFIED PERFORMANCE FIGURES ARE EQUAL TO MOST EXPENSIVE UNITS AVAILABLE.** Frequency response ± 3 D.B. 30-20,000 c/s. Tone Controls ± 12 D.B. at 50 c/cs. ± 12 D.B. to — 6 D.B. at 12,000 c/cs., hum and noise 70 D.B. down. Good quality reliable components used. Chassis finish blue hammer. Overall size 12 × 9 × 9in. approx. Power consumption 150 watts. For A.C. mains 200-250 v. 50 c/s. Outputs for 3 and 15 ohm speakers. **EQUALLY SUITABLE FOR THE CONNOISSEUR OR FOR LARGE HALLS, CLUBS OR OUTSIDE FUNCTIONS, IDEAL FOR USE WITH MUSICAL INSTRUMENTS SUCH AS STRING BASS, ELECTRONIC ORGAN, GUITAR, etc. FOR DANCE BANDS, GARRISON THEATRES, etc., etc. We can supply Microphones, Speakers, etc., at keen cash prices or on terms with amplifiers. EXPORT ENQUIRIES INVITED.**

FULL RANGE OF LINEAR HIGH FIDELITY AMPLIFIERS ALWAYS IN STOCK.

GL3A MINIATURE 3 WATT GRAM AMPLIFIER

For 200-250 v. 50 c.p.s. A.C. mains. Overall size only 11¼ × 2½ × 2¼in. Fitted Vol. and Tone Control with mains switch. Designed for use with any kind of single player or record changing unit. Output for 2-3 ohm speaker. Guaranteed 12 months. Only **59/6.**

R.S.C. A7 3-4 WATT QUALITY AMPLIFIER. Spec. exactly as A5 below with exception of output voltage. Complete kit of parts, diagrams and instructions £3/15/-. carr. 3/6.

R.S.C. A5 4-5 WATT HIGH GAIN AMPLIFIER

A highly sensitive 4-valve quality amplifier for the home, small club, etc. Only 50 millivolts input is required for full output so that it is suitable for use with the latest high fidelity pick-up heads in addition to all other types of pick-ups and practically all makes. Separate Bass and Treble controls are provided. These give full long playing record equalisation. Hum-level is negligible being 71 D.B. down. 15 D.B. of negative feedback is used. H.T. of 300 v. 26 mA. and L.T. of 6.3 v. 1.5 a. is available for the supply of a Radio Feeder Unit or Tape Deck pre-amplifier. For A.C. mains input of 200-250 v. 50 c/s. Output for 2-3 ohm speaker. Chassis is not alive. Kit is complete in every detail and includes fully punched chassis (with baseplate) with the blue hammer finish, and point-to-point wiring diagrams and instructions. Exceptional value at only £4/15/- or assembled ready for use 25/- extra, plus 3/6 carriage. Or Deposit 22/- and five monthly payments of 22/- for assembled unit.

R.S.C. TRANSFORMERS. Fully Guaranteed, Interleaved & Impregnated

WE CAN QUOTE FOR SPECIAL OR STANDARD TYPES IN ANY QUANTITY. OUR FACTORY HAS SUPPLIED LEADING EQUIPMENT MANUFACTURERS AND GOVT. DEPTS. FOR 15 YEARS.

MAINS TRANSFORMERS. Primaries 200-230-250 v. 50 c/s.

FULLY SHROUDED UPRIGHT MOUNTING.

250-0-250 v. 60 mA., 6.3 v. 2 a., 5 v. 2 a. 2½-3-3ins.	17/11
250-0-250 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	27/9
300-0-300 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	27/9
350-0-350 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	27/9
350-0-350 v. 150 mA., 6.3 v. 4 a., 5 v. 3 a.	33/9
425-0-425 v. 200 mA., 6.3 v. 4 a., c.t. 5 v. 3 a.	49/9

TOP SHROUDED DROP-THROUGH TYPE

260-0-260 v. 70 mA., 6.3 v. 2 a., 5 v. 2 a.	16/11
250-0-250 v. 100 mA., 6.3 v. 3.5 a.	19/9
250-0-250 v. 100 mA., 6.3 v. 2 a., 6.3 v. 1 a.	21/9
350-0-350 v. 80 mA., 6.3 v. 2 a., 5 v. 2 a.	18/9
250-0-250 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	25/9
300-0-300 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	25/9
300-0-300 v. 130 mA., 6.3 v. 4 a., c.t., 6.3 v. 1 a., suitable for Mullard 510 Amplifier	29/9
350-0-350 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	25/9
350-0-350 v. 150 mA., 6.3 v. 4 a., 5 v. 3 a.	29/9

ELIMINATOR TRANSFORMERS.

120 v. 40 mA., 5-0-5 v. 1 a.	14/9
90 v. 15 mA., 6-0-6 v. 250 mA.	9/11

FILAMENT TRANSFORMERS

6.3 v. 1.5 a.	5/9	12 v. 1 a.	7/9
6.3 v. 2 a.	7/6	6.3 v. 3 a.	8/11
0-4-6.3 v. 2 a.	7/9	6.3 v. 6 a.	17/9
		12 v. 3 a. or 24 v. 1.5 a.	17/9

AUTO (Step Up/Step Down) TRANSFORMERS

50-80 watts 110-120 v./230-250 v.	11/9
150 watts 110-120 v./200-230-250 v.	27/9

OUTPUT TRANSFORMERS

Midget Battery Pentode 66:1 for 3S4, etc.	3/9
Small Pentode 5,000Ω to 3Ω	3/9
Standard Pentode 5,000Ω to 3Ω	5/9
Standard Pentode 8,000Ω to 3Ω	5/9
Push-pull 8 watts 6V6 to 3 ohms	8/9
Push-pull 8 watts EL84s to 15 ohms	8/9
Push-pull 10-12 watts 6V6 to 3Ω or 15Ω	16/9
Push-pull 10-12 watts to match 6V6 to 3-5-8 or 15Ω	17/9
Push-pull EL84 to 3 or 15 ohms 10-12 watts	17/9
Push-pull Ultra Linear for Mullard 510	27/9
Push-Pull 15-18 watts, sectionally wound, 6L6, KT66, etc., for 3 or 15 ohms	23/9
Push-pull 20 watt high-quality sectionally wound, 6L6, KT66, etc., to 3 or 15Ω	47/9

MICROPHONE TRANSFORMERS

120:1 High quality, clamped	6/9
120:1 High quality Mu metal screened	8/9

SMOOTHING CHOKES

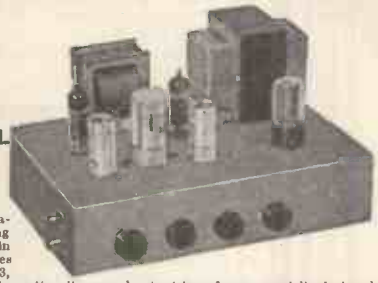
250 mA., 5 H., 100Ω	11/9	80 mA., 10 H., 350Ω	5/6
150 mA., 7-10 H., 250Ω	11/9	60 mA., 10 H., 400Ω	4/11
100 mA., 10 H., 200Ω	8/9	1 amp. 0.5Ω L.T. type	6/6

PARMEKO MAINS TRANSFORMERS. Fully shrouded:

450-0-450 v. 100 mA. 6.3 v. 1.5 a., 4 v. 3 a., 4 v. 2 a.	19/9
500-0-500 v. 120 mA., 6.3 v. 4 a., 5 v. 3a.	31/9

HIGH FIDELITY 12-14 WATT AMPLIFIER TYPE A11

PUSH-PULL ULTRA LINEAR OUTPUT "BUILT-IN" TONE CONTROL PRE-AMP STAGES



Two input sockets with associated controls allow mixing of "mike" and gram. as in A.10 High sensitivity. Includes 5 valves: ECC83, ECC83, EL84, EL84, 5Y3. High Quality sectionally wound output transformer specially designed for Ultra Linear operation and reliable small condensers of current manufacture. INDIVIDUAL CONTROLS FOR BASS AND TREBLE "Lift" and "Cut." Frequency response ± 3 D.B. 30-30,000 c/cs. Six negative feedback loops. Hum level 60 D.B. down, ONLY 23 millivolts INPUT required for FULL OUTPUT. Suitable for use with all makes and types of pick-ups and microphones. Comparable with the very best designs. For STANDARD or LONG PLAYING RECORDS. For MUSICAL INSTRUMENTS such as STRING BASS, GUITARS, etc. OUTPUT SOCKET with plug provides 300 v. 30 mA. and 6.3 v. 1.5 a. For supply of a RADIO FEEDER UNIT. Size approx.: 12.9-7in. For A.C. mains 200-250 v. 50 c/cs. Output for 3 and 15 ohm speakers. Kit is complete to last nut. Chassis is fully punched. Full instructions and point-to-point wiring diagrams supplied. (Or factory built 45/- extra). ONLY **8 Gns.** Carr. 10/-. If required louvred metal cover with 2 carrying handles can be supplied for 18/9. TERMS ON ASSEMBLED UNITS. DEPOSIT 24/3 and 9 monthly payments of 24/3. Send S.A.E. for illustrated leaflet detailing Ready-to-assemble Cabinets. Speakers, Microphones, etc., with cash and credit terms.

R.S.C. PORTABLE GUITAR AMPLIFIERS

JUNIOR 5 WATT. High Quality Output. Separate Bass and Treble "cut" and "boost" controls Sensitivity 15 mv. High Flux 8in. l/speaker. Input sockets for Radio/Tape or Gram Pick-up and Mike /Instrument Pick-up. Handsome strongly made cabinet (size approx. 14 × 14 × 7in.). Finished in satin walnut and fitted carrying handle. **£8/19/6** Carr. 7/6. Or Deposit £1 and nine monthly payments £1. Send S.A.E. for leaflet.

SENIOR 10 WATTS. High-Fidelity Push-Pull output. Separate Bass and Treble "cut" and "boost" controls. Twin separately controlled high gain inputs so that two instruments such as Guitar and String Bass can be used at the same time. Two Loudspeakers are incorporated a 12in. P.M. for Bass notes, and 1 7 × 4in. elliptical for Treble. Cabinet is well made and finished satin walnut. Size approx. 18 × 18 × 8in. 15 Gns. Plus 10/- carr. H.P. TERMS. DEPOSIT 34/9 and 9 monthly payments 34/9. Both models for 200-250 v. A.C. mains.

COLLARO CONTINENTAL 4 SPEED DE LUXE MIXER AUTO-CHANGERS with TX88 Transcription Cartridge for standard and L.P. records. For normal 200-250 v. A.C. mains. Few only at unrepeatable price of **£10/19/6.** Carr. 4/6.

COLLARO CONQUEST 4-SPEED AUTO-CHANGERS. With studio pick-up with turnover head. Latest model for 200-250 v. A.C. mains, £6/19/6 Carr. 4/6.

B.S.R. MONARCH AUTO-CHANGERS. Type UA8. 4 speed T/O Pick-up with sapphire stylus £6/19/6. Carr. 4/6.

Any of the above supplied with T/O stereo/monaural head for £1 extra.

COLLARO JUNIOR. 4-speed Single Players with Hi-Fi T/O crystal pick-up head, £3/19/6.

LOUDSPEAKER IN POLISHED WALNUT FINISHED CABINET. Gauss 12,000 lines. Speech coil 3 ohms or 15 ohms. Only £4/19/6. Carr. 5/-. TERMS: DEPOSIT 11/- and 9 monthly payments of 11/-.

12in. 20 WATT 15,000 line l/speakers 15 ohms in Cabinet finished as above. Size 18 × 18 × 8in. £7/19/6 or Deposit 17/9 and 9 monthly payments of 17/9.

ACOS HGP59 Hi-Fi Crystal Cartridges. (Turnover type with sapphire stylus). Standard replacement for Garrard and Collaro. Only 19/9. B.S.R. Ful-Fi 19/9. Garrard GC2 19/9. Acos Stereo/monaural 49/9.

ACOS HIGH FIDELITY PICKUPS. GP54 with HGP59/52 Cartridge. Turnover sapphire styli, cream finish. Limited number at approx. half price. Only 35/9.

R.C.A. TRANSCRIPTION PICK-UPS. Variable Reluctance type for standard and L.P. Records. Normal price approx £14. Limited number brand new perfect at £3/19/6.

PLESSEY DUAL CONCENTRIC 12in. P.M. SPEAKERS

(15 ohms), consisting of a high quality 12in. speaker of orthodox design supporting a small elliptical speaker ready wired with choke and condensers to act as tweeter. This high fidelity unit is highly recommended for use with our A11 or any similar amplifier. Rating is 10 watts. Gauss 12,000 lines. Price only £5/19/8. Or Deposit 13/9 and 9 monthly payments of 13/9

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TERMS: C.W.O. or C.O.D. No C.O.D. under £1. Postage 1/9 extra on all orders under £2, 2/9 extra under £5 unless carriage stated. Trade supplied. Post orders to: **Mail Order Dept.**
29-31 Moorfield Road, Leeds, 12.

RCA AR88 RECEIVERS.

One of the most renowned American Communications Receivers ever manufactured. Widely used by all the Armed Services to maintain World-wide Communications and Monitoring Posts under all conditions. Employs 14 valves, and has 6 switched overlapping wave bands for complete coverage. Refinements include Mechanical Band Spread with Logging Scale, Automatic or Manual Volume Control. Automatic or Manual Noise Limiter, BFO with pitch control, RF and AF Gain Controls, Variable HF Tone Control, Variable Selectivity with Crystal Filter, Aerial Trimmer, Choice of Headphones or Speaker. Has internal mains power pack for nominal 115-230 volts A.C. In Black Crackled Case,size 19¼in. W. x 11in. H. x 19¼in. D. Thoroughly reconditioned, immaculate in appearance, and in perfect working order. " D " Model covers 500 kc/s-32 Mc/s, price £45. " LF " Model covers 75-550 kc/s. and 1.5-30.5 Mc/s. Price **£35** (add carriage 30/- and 50/- deposit on returnable transit case). S.A.E. brings illustrated descriptive leaflet.

R1155 RECEIVERS.

The famous Bomber Command Receiver known the world over to be supreme in its class. Covers 5 wave ranges: 18.5-7.5 Mc/s 7.5 -3.0 Mc/s. 1,500-600 kc/s., 500-200 kc/s., 200-75 kc/s. and is easily and simply adapted for normal mains use, full details being supplied. All sets thoroughly tested and in perfect working order before despatch, and on demonstration to callers. Fitted with latest type Super Slow Motion tuning assembly. Have had some use, but are in excellent condition. ONLY £9/19/6.
A.C. MAINS POWER PACK OUTPUT STAGE in black metal case to match receiver, enabling it to be operated immediately by just plugging in, without any modification. Fitted with 8in. P.M. speaker £6/10/-. DEDUCT 10/- IF PURCHASING RECEIVER AND POWER PACK TOGETHER.
Send S.A.E. for illustrated leaflet, or 1/3 for 14-page booklet which gives technical information, circuits, etc., and is supplied free with each receiver. Add carriage 10/6 for Receiver, 5/- for Power Unit.

RCA 8in. P.M. SPEAKER in heavy black crackled metal case, size 11½in. x 10½in. x 6in. Designed for use with AR88 Receiver or any set with 3 ohms output. BRAND NEW IN MAKER'S CARTONS. ONLY 45/-. (Post 3/6).

CANADIAN MOVING COIL PHONES. Low resistance, fitted noise excluding chamois ear muffs, and leather covered head-band. Lead terminates to jack plug. BRAND NEW. ONLY 19/6 (Post 1/6).

OSCILLOSCOPE No. 11 by Cossor. A First Grade L.F. Oscilloscope incorporating a Hard Valve Time Base with speeds of 1-5-40 milliseconds but easily converted for a few shillings to produce 3 c.p.s. to 30 kc/s. Has High Class Amplifier with Fine and Coarse Gain controls, Brightness and Focus controls, X and Y shifts. A.C. mains pack for 115 v. -230 v. nominal, fully fuse protected. Employs 2½in. Tube ACR 10, Front panel 19in. x 7in. for rack mounting, depth 12in., or can be used in Steel Transit Case on bench. Complete with suggested Modification data. BRAND NEW AND UNUSED. ONLY £12/10/- (carriage 15/-).

CARRYING CASES, solid leather. SLIGHTLY USED. Internal dimensions 8½in. H. x 8½in. W. x 4½in. D. Fitted lock and key, and shoulder strap. Ideal for Test Instrument, Camera and accessories, etc. ONLY 25/- (postage 2/-).

BC 342 RECEIVERS. A few only of these famous American sets covering 1.15-18.0 Mc/s. in six bands. Internal 115 v. A.C. Mains pack. A super receiver in first-class condition and perfect working order, ONLY £25 (carriage 15/-).

HRO MAINS POWER UNITS. A.C. Input 115/230 volts, Output D.C. (fully smoothed) 230 volts 75 mA., and 6.3 volts 3.5 amps. Complete in black crackled case ONLY 59/6.

12-WAY SCREENED CABLE. In 10ft. lengths, fitted with plugs, originally made for No. 19 Wireless Set. UNUSED. ONLY 15/- per lead.

P.M. SPEAKERS. 3in. 19/6, 6½in. 17/6, 8in. 21/-, 12in. 29/6.

SPRAGUE CONDENSERS. Metal cased wire ends. New. .01 mfd. 1,000 v. and .1 mfd. 500 v. 7/6 per dozen. Special quotes for quantities.

HETERODYNE FREQUENCY METERS TYPE LM14

Frequency range 125-20,000 kc/s. in 2 bands. This is the United States Navy Model of the well-known BC.221 Frequency Meter, but has many additional features which increase its usefulness. Voltage stabilisation circuits and Crystal control ensure extreme accuracy, and in addition it is fitted with an Internal Modulation switch to allow use as a Signal Generator. Size only 8½in. x 8in. x 8½in. Full information on request.

10,000 OHMS PER VOLT TESTMETER

This latest Caby model is a handy pocket sized tester 5½ x 3½ x 2½in. Reads low D.C. voltages at 10,000 ohms per volt, up to 1,000 v. A.C. and D.C. at 4,000 o.p.v. Resistance to 20 megs. D.C. current to 250 milliamps and also Decibels. Complete with Test Leads, Batteries and Instruction Book. ONLY £6/10/-.

DOUBLE BEAM OSCILLOSCOPE TUBES

Type CV 1596 equivalent to Cossor O9D as used in oscilloscopes by Cossor (339 series). Hartley and Erskine (13 series). Listed at £12/10/-.

Our price £2/19/6 (carriage 5/6)

Brand new in makers' crates

W 1191A WAVEMETER

Crystal controlled heterodyne frequency meter covering 100 kc/s to 20 Mc/s. in 8 switched bands and is virtually the British BC221. Power requirements 2 v. L.T. and 40-60 volts H.T. Complete with Calibration Book, Crystal, Operating Valves and full set of spares. BRAND NEW IN ORIGINAL TRANSIT CASES. ONLY £9/19/6 (carriage 15/-).

METERS

F.S.D.	SIZE AND TYPE			PRICE
25 microamps	D.C.	2½in. Proj.	circular	59/6
50 microamps	D.C.	2½in. Flush	circular	59/6
50 microamps	D.C.	3½in. Flush	circular	80/-
100 microamps	D.C.	2½in. Flush	circular	39/6
1 milliamp	D.C.	2in. Flush	square	22/6
1 milliamp	D.C.	2½in. Flush	circular	30/-
1 milliamp	D.C.	2½in. Flush	circular	25/-
1 milliamp	D.C.	3½in. Flush	circular	50/-
200 milliamp	D.C.	2½in. Flush	circular	12/6
20 amps	D.C.	2in. Proj.	circular	7/6
40 amps.	D.C.	2in. Proj.	circular	7/6
5 amps	D.C.	2in. Flush	square	12/6
300 volts	A.C.	2½in. Flush	circular	25/-
500 volts	A.C.	2½in. Flush	circular	25/-

V.H.F. RECEIVER TYPE R.1392. A superb 15-valve superhet receiver covering 95-150 Mc/s. (2-3 Metres), being fully tunable over that range, with provision for Crystal Control. Has 2 stages of R.F., 3 of I.F., BFO, AGC, etc. Fitted with 2in. square meter for Oscillator and Audio Signal checking. Size 19in. x 10in. x 10in. Used but in very good order, thoroughly air tested before despatch. Power supply required: 240-250 volts at 80 mA., and 6.3 volts at 4 amps. Complete with valves and circuit diagram. ONLY 79/6 (carriage, etc., 10/6).

HIGH FREQUENCY A.C. VOLTMETER. A first-grade moving iron instrument with 6in. Mirror Scale reading up to 150 volts A.C. at 400 and 1,200-2,400 cycles. In substantial oak case with removable lid, overall size 8½in. x 8½in. x 5½in. Recently made for the Air Ministry by Everett Edgcumbe Ltd., and in perfect order. Brand new and unused. ONLY £7/10/-. Can also be supplied for 50 cycles use, either 0-150 volts or 0-300 volts, same price.

POWER UNIT TYPE 3. Primary 200/250 volts A.C., 50 cycles. Outputs of 250 volts 100 mA., and 6.3 volts 4 amps. Fitted double smoothing and 2 meters to read H.T. current and voltage. For normal rack mounting (or bench use) having grey front panel. Size 19in. x 7in. BRAND NEW. ONLY 79/6 (carriage 7/6).

INTERCOM. TELEPHONE SET. Two pairs of Brand New Headphones connected to Breast Microphones, with leads, etc., in fitted carrying cases. Supplied with 4½ volt battery, 10 yards twin flex, and full instructions for connecting to make super intercom. ONLY 27/6. (Post 3/6). Extra flex 3d. per yard.

RECEIVER R107. A few more of these fine receivers. 9 valves, 3 wavebands covering 1.2-17.0 Mc/s. (18-250 metres), incorporating built-in speaker and 2 power packs for use on 100-250 volts A.C. or 12 volts D.C. In magnificent condition, the finest we have yet had ONLY £15 (carriage £1). A few soiled sets at lesser prices to callers only.

12 VOLTS AMERICAN DYNAMOTOR. Delivers 220 volts at 100 mills. Size 5½ x 3½in. diameter. Ideal for running Radio and Electric Shaver, etc., from car batter. ONLY 32/6.

MARCONI SIGNAL GENERATOR TF 144G/7. Coverage 85 kc/s.-2.5 Mc/s. and 8 Mc/s.-70 Mc/s. Complete, and in AS NEW CONDITION. ONLY £95.

AMPLIFIER N24

Utilises 4 valves, 1 each 5Z4G, 6V6G, 6J7G, 6J5G and high quality components such as "C" Core Transformers and Block Paper Smoothing Condensers. A.C. Mains Pack for nominal 110 x 230 volts. Provision for 600 ohms or High Impedance input. Output to 600 ohm Line. For normal use only requires changing Output Transformer. Output approximately 4 watts. Designed for Standard Rack Mounting, having grey front panel size 19in. x 7in. All connections to rear panel, front having " On/Off " Switch. Gain Control, Indicator Light. Fuses and Valves Inspection Panel. BRAND NEW IN MAKER'S PACKING. ONLY £4/9/6 (carriage 10/6).

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EQUALLY SENSATIVE ON MEDIUM AND LONG WAVE BANDS

SPECIFICATION

- 425mW Push-Pull Output
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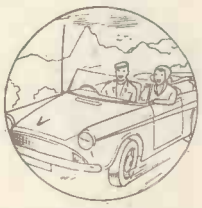
- New Type Printed Circuit with all Components Marked
- Full Medium and Long Wave Tuning
- High "Q" Internal Ferrite Aerial
- Car Radio Adaptation and AVC
- Slow Motion Fingertip Tuning
- "Hi-Fi" Quality Speaker
- Size 9½ x 7½ x 3½in. Weight 4½lb.

ALL COMPONENTS AVAILABLE SEPARATELY

Wherever you are

"First Class in every way"



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CALL FOR DEMONSTRATION

- ★ STEP BY STEP FULLY ILLUSTRATED INSTRUCTIONS
- ★ ALL COMPONENTS GUARANTEED
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Total Cost of all Components
£11.10.0 P.P. 3/6
including Cabinet, Battery Transistors, Car Radio, AVC and all necessary items.

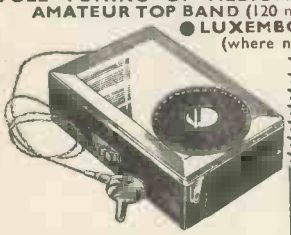
- ★ SIMPLE TO CONSTRUCT
- ★ NO TECHNICAL KNOWLEDGE REQUIRED
- ★ WORTH DOUBLE WHEN BUILT
- ★ EXCELLENT RESULTS ANYWHERE

DESCRIPTIVE LEAFLET FREE ON REQUEST

★ RANGER-3 ★ PERSONAL POCKET RADIO

FULL TUNING OF MEDIUM WAVEBAND AND AMATEUR TOP BAND (120 metres to 500 metres)

● LUXEMBOURG GUARANTEED (where normally receivable)



- ★ Full Station Separation
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- ★ Fingertip Control
- ★ 6 Months' Battery Life
- ★ Fitted Volume Control
- ★ 3 High Gain Transistors
- ★ Size 4⅜ x 3 x 1½in.

TOTAL COST with Personal Earphone, Battery Transistors, etc.
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Continental as well as local stations—*GUARANTEED!*

MEDIUM LONG AND SHORT WAVE

SEVEN TRANSISTOR SUPERHET

★ **PRE-BUILT UNITS** ★

—THE NEW EASY WAY TO BUILD A RADIO—

- Press Button Short, Medium and Long Wave Coil Pack: OC170 OSC/Mixer stage. Printed Circuit. Pre-aligned and Tested. **67/6** P.P. 1/6. Plus **22/9** P.T.
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● SPECIAL OFFER ●		● SPECIAL OFFER ●	
6 EDISWAN TRANSISTORS AND TWO DIODES		**6 MULLARD TRANSISTORS AND TWO DIODES**	
1—XA102		1—OC44	
2—XA101	ONLY	2—OC45	ONLY
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2—XC101	PER SET	2—OC72	PER SET
and 2 Diodes	P.P. 1/-	and 2—OA81	PP. 1/-

CRYSTAL MICROPHONE INSERTS

Fully Guaranteed

- ★ ACOS, 43-1, 2½in. round **12/6**, P.P. 6d.
- ★ ACOS, 14-9, 1½in. round **7/6**, P.P. 6d.
- ★ ACOS, ½in x ⅜in. ..... **7/6**, P.P. 6d.
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"STEREO 3-D"

STEREO RECORD PLAYER AMPLIFIER

New high-gain circuit with full tone, balance and volume controls. Can be used with all types of records as well as stereo.

- ★ 2 WATTS PEAK PER CHANNEL
- ★ ECC83; 2-ECL82 VALVES
- ★ MAINS 110/250V A.C.

Complete with speaker sockets, calibrated dials, etc. **£5.7.6**
BUILT and TESTED P.P. 2/-.

★★ **COLLARO 4-SPEED STEREO AUTO-CHANGER**, ideal for use with above amplifier **£7/10/0**, P.P. 3/6.
★★ 9 x 6in. large magnet Elac speaker, for use with STEREO 3-D, 37/- pair. P.P. 1/6.

PRACTICAL TRANSISTOR CIRCUITS

No 2. GADGETS, AMPLIFIERS, TRANSMITTERS, RECEIVERS, TEST UNITS **All transistor**

Now contains 40 Easy to Build Transistor Circuits for the home constructor with diagrams and prices.

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TRANSMITTER/RECEIVER
Army Type 17 Mk. II

Complete with Valves, High Resistance Headphones. Handmike and Instruction Book and circuit. Frequency range 44.0 to 61 Mc/s. Range approximately 3 to 8 miles. Power requirements: Standard 120 v. H.P. and 2 v. L.T. Ideal for Civil Defence and communications.
BRAND NEW
45/- P.P. 5/-.

931A (27M1) PHOTO - MULTIPLIER

BRAND NEW, ORIGINAL CARTONS
80/- P.P. 1/-. BASE 2/-

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FOR TRANSMITTING RADIO CONTROL, OSCILLATORS, ETC.

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FAMOUS TAPE RECORDER

LISTED 29 gns. NOW **18 gns.**

UNREPEATABLE VALUE

Famous manufacturer. Huge purchase allows us to offer at this amazing price. Beautifully styled, rexine covered cabinets. Colours: Red, Grey, Black. Storage space for 4 tapes, mike and lead. Incorporating the latest B.S.R. Deck. LOOK AT THESE EXPENSIVE FEATURES. Controls: Record/Playback switch and rewind with interlocking device to prevent accidental erasure. Tone and volume controls. Superimpose and electronic eye. Small overall size 14½ × 14½ × 7½in. Lightweight, only 21lb. 5½in. standard tape. Terms: Carr. & Ins. 12/6. Microphone 27/6 extra. Tapes 19/9.

PLESSEY T.V. CHASSIS FOR SPARES 9'6

56 resistances. 54 condensers. 13 valve holders. 4 transformers. Chokes 250 ma. Metal rectifiers 300 volts @ 250 ma. Fuse panel. Focus magnets. Plugs. Sockets. Carr. 7/6.

REPLACEMENT, REBUILT T.V. TUBES 12 months guarantee

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21in. tube £8/10/-. 17in. tube £7/10/-. £2 allowed on old tube. 12, 14, 15in., tubes £5/10/-. £1 allowed on old tube. Terms available over 20 weeks.

CONTEMPORARY EXTENSION SPEAKERS 19/9

Ideal for extra stereophonic speaker, covered in smart two-tone leatherette. Beautifully made. Including 8in. speaker. P. & P. 3/9.

EXTENSION SPEAKERS 19/9

8in. P.M. Speakers fitted into polished cabinets. Standard matching to any receiver. (Complete.) Switch and flex included. P. & P. 3/9.

BARGAIN SPEAKER 5/9
8in. P.M. Repaired cone defect not affecting reproduction quality.

8in. P.M. SPEAKER 6/9
As above but with output transformer.

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Perfect quality. Fitted output transformer.

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8 × 3in. and 7 × 4in. Brand new Also 9 × 4in. @ 19/9.
P. & P. on each 2/9.

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X.W.D. Wireless remote control unit. E.M.K.II (ZA11954). Including morse tapper, switched, jack plugs, etc. Less phone. Ins. and carr. 3/6.

DELUXE TAPE RECORDER

LISTED 31 gns. our price **22 gns.**

Beautifully styled rexine covered cabinet in Red/Beige with carrying handle. Size: 14½ × 13 × 9½in. Storage comp. in lid for tapes and mike. Speed 3¾in. per second. Compact set using latest 5 valve amplifier with 4-stage amplification and separate valve for Bias osc. 2 controls. Contains 7 × 4in. elliptical speaker and incorporating B.S.R. Tape deck. 5¾in. standard tape. 3 months' guarantee. Ins. & Carr. 12/6. Deposit £8 plus Ins. Carr. and 20 payments of 17/-.

DELUXE TAPE RECORDER CABINET

ONLY **29/9**

Beautifully made Tape Recording Cabinet. Size: 13 × 10½ × 7in. Covered in two-tone coloured rexine cloth. Stylish design. Carrying handle with detachable lid. Easily adapted to Record Player Cabinet. Exceptional value at this very low price. P. & P. 4/6.

17" T.V.'s 17½ gns.

Modern CHASSIS, modified

Complete 17in. TUBE. VALVES — SPEAKER — KNOBS. Tuned ITV/BBC. Ready to use, fully guaranteed, TUBE 12 months, CHASSIS and VALVES 3 months. Cabinet to fit £1/11/6 if ordered with set. Salvage. Set—tube—cabinet despatched separately. Carr. & Ins. on set £1/5/-; on Cabinet 8/6.

SOLO SOLDERING TOOL 12'6

110 v., 6 v. or 12 v. (special adaptor for 200/250 v., 10/- extra). Automatic solder feed including 20ft. reel of Ersin 60/40 solder and spare parts. It is a tool for electronic soldering or car wiring. Revolutionary in design. Instantly ready for use and cannot burn. In light metal case with full instructions for use. Post 3/6.

RECORD PLAYER CABINET R.P.9 19/6

Exceptional offer. A lightweight portable player Cabinet in two-tone Rust and Cream. Famous manufacturer. Size: 14½ × 11½ × 6in. Complete with moulded deck board of attractive design. Takes B.S.R. TU9 single player; 2 control Amplifier; 5in. round Speaker. Post, Packing & Ins., 4/6.

"STUDIO TWIN" ~~40 gns~~ NOW 29 gns.

Quality Twin Speaker Tape Recorder at this amazing reduced price. 7in. 1,200ft. Standard reels. Latest Studio 3-speed Deck, 1⅞, 3¾, 7½ I.P.S. Includes Twin Tracks, Reverse counter, Pause control and magic eye recording indicator. Volume and tone control, superimpose switch. Two matched speakers. 3 watts output. Attractive design cabinet in beige. Size 19in. × 13in. × 8in. Ins. & Carr. 12/6.

EXTRAS: Microphone 27/6. Tape 25/-.

B.S.R. TAPE "MONARDECK" £9.9.6

Single speed. 3¾in. per sec. Uses 5in. spools. Complete with Record-Playback and erase heads. Simple control for R/P.B. and fast rewind with safety switch for record. Size: 13 × 8¾ × 2½in. Colours: two-tone grey. P. & P. 4/6. Deposit 60/- plus P. & P. and 20 weeks at 8/-.

TAPE RECORDER AMPLIFIER £7.19.6

Compact, well designed 5 valve amplifier. Output 3.5 watts. Valve line up—ECC83, double triode first audio amplifiers, ECL82 triode pentode further audio amplifier and output valve, 6BW6 bias and erase oscillator, EM84 record level indicator. EZ80 H.T. rectifier. Input for mike, radio and gram. Controls: record playback volume and on/off playback tone. Dia. 8½ × 3 × 4¾in. ins. and carr. 4/6. Terms.

EXTRAS: Knobs 2/6 per set. Beautiful Perspex dial plate, Complete with sockets for mike, radio and superimposed switch 3/6.

AMPLIFIERS. All portable. 12 months guarantee

MK. D5. 39/6
Simple circuit employing ECL80 triode pentode output valve giving 3 watts output. A.C. only. Mains isolated. Single control for volume and on/off switch with knob. P. & P. 3/6.

MK. D2A. 79/6
Latest design incorporating negative feedback, giving 4 watts undistorted output. Valves: ECL82, triode pentode and contact cooled metal rectifier. Tone and volume control panel on flying leads with compact amplifier chassis suitable to mount under modern autochangers to give easy mounting in small cabinet. A.C. only. Mains isolated. Output for 2-3 ohms.

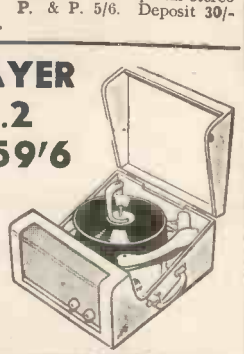
MK. D3A. 89/6
As above de luxe model, with separate tone controls for treble and bass.

PORTABLE AMPLIFIER (Salvage) 69/7
3 valves. 4-5 watts output. Size 7 × 5 × 4in. An ideal amplifier for stereo record players, Tape Recorders, Microphone, Baby Alarm, etc. Volume and tone controls. 200-250 v. A.C./D.C. P. & P. 4/6.

NEW LOOK AMPLIFIER 99/6

Ideal stereo attachment. Brown/Ivory cabinet, carrying handle. Contains high flux 8in. speaker. A.C. mains. 3 valves—10F3, 10P14, U404. Max. output 4.5 watts. 14 × 11 × 6½in. Completely converted. Ideal stereo, Mike, Guitar, Records. 2 units give world of amusement and special stereo effects. 12 months' guarantee. P. & P. 5/6. Deposit 30/- plus P. & P., 10 weeks at 8/-.

RECORD PLAYER CABINET R.P.2 FOR ONLY 59'6



Made by famous manufacturer. In polka dot cloth with clipped lid and carrying handle. Size: 16 × 14½ × 8½in. deep. Carr. & Ins. 4/6 Will take B.S.R. Monarch Autochanger, £6/19/6; 7in. × 4in. Elliptical Speaker 15/9; Our Mk. D2A Portable Amplifier 79/6.

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For Cathode Ray Tubes having Heater/Cathode short circuit and for C.R. Tubes with falling emission. Full instructions supplied.

Type A. Low Leakage windings. Optional Boost 25% and 50%. Tapped mains primaries:

2 volt	12/6 each
4 volt	12/6 each
6.3 volt	12 6 each
10.8 volt	12/6 each
13.5 volt	12/6 each

OUR LATEST SUPERIOR PRODUCT. Type A2. High Quality. Low capacity, 10/15 pf. Optional boost 25%, 50%, 75%. **16/6** each

Type B. Mains input. Low capacity. Multi Output 2, 4, 6.3, 10 and 13 volts. Optional boost 25% and 50%. Suitable for all Cathode Ray Tubes 21/-.

RESISTORS. All preferred values. 20% 10 ohms to 10 meg., ½ w., 4d.; ¼ w., 4d.; 1 w., 6d.; 1½ w., 8d. 2 w. 1/-.
HIGH STABILITY. ½ w., 1%. 2/-. Preferred values 10 ohms to 10 meg., Ditto 5% 9d., 100Ω to 5 meg.

5 watt, 10 watt, 15 watt } WIRE-WOUND RESISTORS 2Ω ohms—10,000 ohms. { 1/3, 1/6, 2/-

12,500 ohms.—50,000 ohms. 10 w. 3/3

WIRE-WOUND POTS, 3 w. Pre-set Min. T.V. type Knurled Slotted knob. All values 25 ohms to 25K., 3/- ea., 30 K. 50 K., 4/-. Ditto ¼ w. Carbon Track 30 K. to 2 Meg., 3/-.

WIRE-WOUND POTS 4 w. Standard size Pots. long Spindle High Grade. All values 100 ohms to 50 K 6/6; 100 K. 7/6.

W/W EXT. SPEAKER CONTROL 10 Ω. 3/-.

O/P TRANSFORMERS. Heavy duty 50 mA. 4/6. Multi-ratio push-pull 7/6. Miniature 3V4, etc. 4/6. Hygiade Push-Pull 10 watts, 15/6. Push-pull 20w. 6k. or 8k. 30/-.
L.F. CHOKES (a) 10H 60/65 mA.. 5/-. 10H 85 mA., 10/6. 10 H 120 mA., 12/6. 10H 150 mA., 14/-.

MAINS TRANSFORMERS 200/250 v. A.C.

STANDARD 250-0-250, 80 mA. 6.3 v. 3.5 a. tapped 4 v. 4 a. Rectifier 6.3 v. 1 a., tapped 5 v. or 4 v. 2 a. Ditto 350-0-350	22/6
MINIATURE 220 v. 20 mA., 6.3 v. 1 a.	10/6
MIDGET, 220 v. 45 mA., 6.3 v. 2 a.	15/6
SMALL, 200-0-200 50 mA. 6.3 v. 2 A.	17/6
STANDARD, 250-0-250, 65 mA., 6.3 v. 3.5 a.	17/6
HEATER TRANS., 6.3 v. 1½ a., 7/6; 3 amp.	10/6
GENERAL PURPOSE LOW VOLTAGE. Outputs 3, 4, 5, 6, 8, 9, 10, 12, 15, 18 24 and 30 v. at 2 A.	22/6

ALADDIN FORMERS and cores, ¼in., 8d.: ⅜in., 10d. 0.3in. FORMERS 5/37 or 8 and Cans TV1 or 2. ½in sq. × 2½in or ½in. sq. × 1½in., 2/- with cores.
SLOW MOTION DRIVES. Epicyclic ratio 6 : 1, 2/3.
SOLON. Midget Soldering Iron, 220/40 v. 25 w., 24/-.
REMPLOY INSTRUMENT IRON. 220/40 v. 25 w., 17/6.
MAINS DROPPERS. 3 × 1½in. Adj. Sliders .3 amp. 1,000 ohms 4/3. .2 amps. 4/3. .1 amp. 2,000 ohms, 5/-.
LINE CORD. .3 amp. 60 ohms per foot .2 amp.. 100 ohms per foot, 2-way, 6d. per foot, 3 way 7d. per foot.

CRYSTAL MIKE INSERT by Acos 6/6

Precision engineered. Size only ⅞ × 1⅜ in.

ACOS CRYSTAL STICK MIKE 39-1. Bargain 35/-.

MIKE TRANSF. 50 : 1, 3/9 ea.; 100 : 1 Potted 10/6.
LOUDSPEAKERS PM. 3 OHM. 5in. Rola, 17/6.
6in. × 4in. Rola, 18/- 7in. × 4in. R.A., 21/-.
10in. × 6in. Rola 27/6. 8in. Plessey, 19/6.
6½in. Rola, 18/6. 8in. Rola. 21/-. 10in. R.A 30/-.
HI-FI TWEETERS, 4in. 25/-. 12in. Plessey, 30/-.
12in. Baker 15 wt. 3 ohm. and 15 ohm models, 90/-.
12in. Baker foam suspension 15 w. 15 ohm. £8.
12in. 15 ohm Plessey 10 wt., 45/-. E.M.I. 14 × 8in. 45/-.

I.F. TRANSFORMERS 7/6 pair

465 kc/s. slug tuning miniature can 2½ × 1 × 1in. High Q and good bandwith. By Pye Radio. Data sheet supplied.

Wearite M800 I.F. Miniature 465 kc/s., 12/6 pair.
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CRYSTAL DIODE G.E.C., 2/-. GEX34, 4/-. 40 Circuits 3/-.
H.R. HEADPHONES. 4,000 ohms, brand new, 15/- pair.
SWITCH CLEANER Fluid, squirt spout, 4/3 tin.
TWIN GANG CONDENSERS. 365 pf. Miniature, 1¼in. × 1¼in. × 1⅛in., 10/-. .0005 Standard with trimmers, 9/-; less trimmers 8/-. Midget 7/6; Single 50 pf. 2/6: 100 pf., 150 pf., 7/-. Solid dielectric 100, 300, 500 pf., 3/6.
VALVE HOLDERS. Pax. int. Oct. 4d. EF50, EA50 6d. B12A, CRT. 1/3. Eng. and Amer. 4, 5, 6, 7 pin, 1/-.
MOULDED Mazda or Int. Oct. 6d. B7G, B8A, B8G, B9A, 9d. B7G with can, 1/6; B12A, 1/3. B9A with can, 1/9.
CERAMIC, EF50, B7G, B9A, Oct., 1/-. B7G, B9A Cans, 1/-.
SPEAKER FRET. Gold Cloth 17in. × 25in., 5/-, 25in. × 35in. 10/-. Tygan 54in. wide. 10/- ft. 27in. wide, 5/- ft. Samples, S.A.E.
WAVECHANGE SWITCHES

2 p. 2-way, or 3 p. 2-way; short spindle	2/6
5 p. 4-way, 2 wafer, or 3 p. 11-w. 3 wafer, long spindle	6/6
2 p. 6-way, or 4 p. 2-way, or 4 p. 3-way, long spindle	3/6
3 p. 4-way or 1 p. 12-way, long spindle	3/6

Wave change "MAKITS" 1 wafer. 8/6; 2 wafer, 12/6: 3 wafer 16/-; 4 wafer 19/6; 5 wafer 23/-; 6 wafer 26/6.
TOGGLE SWITCHES. S.P., 2/-; D.P., 3/6; D.P.D.T., 4/-; MORSE KEYS, good quality, 2/6.
SUB-MINIATURE ELECTROLYTICS (15 v.), 1, 2, 4, 5, 8, 25, 50 mfd., 100 mfd. 3/- each.

THE HI-GAIN BAND 3 PRE-AMP

Cascode circuit using Valve ECC84. 17db gain. Kit 29/6 less power; or 49/6 with power pack. Plans only 6d.
Also Band I version same prices.
(PCC84 Valve if preferred)

1960 RADIOGRAM CHASSIS

THREE WAVEBANDS S.W. 16 m.—50 m. M.W. 200 m.—600 m. L.W. 800 m.—2,000 m. 12-month Guarantee. A.C. 200/250 v., 4-way switch. Short-Medium-Long-Gram. Feedback, 4.2 watts. Chassis 13½in. × 5½in. × 2½in. Glass Dial Size 10 × 4½in. horizontal or vertical. Two Pilot Lamps. Four Knobs. Walnut or Ivory. Aligned and calibrated. Chassis isolated from mains.

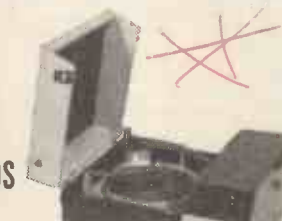
FIVE VALVES LATEST MULLARD ECH81, EBF89, EBC81, EL84, EZ80

BRAND NEW £9. 10. 0 Carr. 4/6

MATCHED SPEAKERS 8in. 17/6; 10in. 25/-; 12in. 30/-.

MONARCH RECORD PLAYER

SAVE POUNDS



BUILD IT YOURSELF using BSR MONACH AUTOCHANGER
READY BUILT 3W. AMPLIFIER
HANDSOME PORTABLE CASE
HIGH FLUX 6" LOUDSPEAKER

FULL INSTRUCTIONS supplied

Total Price Carr. and Ins. 5/- **£12 . 10 . 0**

RECORD PLAYER BARGAINS

4 Speed Autochangers, BSR, U.A.8	£6	15	0
Stereo U.A.8	£7	10	0
Collaro Conquest	£7	19	6
Garrard Model 210	£10	10	0
4 speed Single Players, EMI	£6	19	6
Garrard TA Mk. II	£8	8	0
Garrard 4 HF Transcription	£17	19	6

Garrard Stereo Heads £2 extra.

AUTOCHANGER ACCESSORIES

Suitable player cabinets (uncut boards)	49/6
Amplifier player cabinets with cut boards	63/-
2-valve amplifier and 6½in. speaker for above	79/6
3-valve amplifier and 6½in. speaker for above	95/-

Wired and tested ready for use.

GYLDON TURRET TELETUNER

14 33/38 mcgs, complete with frame-grid valves. With coils for channels 1 to 5 & 8 to 11. Brand new. price 45/-, operating data & circuit supplied.

VOLUME CONTROLS

Midget size:
Long spindle. Guaranteed 1 year. All values.
5 K. ohms up to 2 Meg. No switch. D.P. 8w. 3/- 4/6
Linear or Log Tracks.

80 Ohm Cable Coaxial

Semi air spaced, ⅜in. dia. Ideal Band III **6d.** yd. Losses cut 50% Post 1d. per yard extra.
FRINGE QUALITY AIRSPACED .... 1/- yd.

COAXIAL PLUGS.... 1/- LEAD SOCKETS.. 2/-
PANEL SOCKETS .... 1/- OUTLET BOXES .. 4/6
BALANCED TWIN FEEDER per yd. 6d., 80Ω or 300.
TWIN SCREENED BALANCED FEEDER 1/6 yd., 80 ohm.

ALUMINIUM CHASSIS. 18 s.w.g. Plain, undrilled, with 4 sides, riveted corners and lattice fixing holes, with 2½in. sides 7 × 4in. 4/6; 9 × 7in., 5/9; 11 × 7in., 6/9; 13 × 9in., 8/6; 14 × 11in., 10/6; 15 × 14in., 12/6 and 18 × 16 × 3in., 16/6.

BLACK CRACKLE PAINT. Air drying, 3/- tin.
P.V.C. CONN. WIRE, coloured, single or stranded 2d. yd.
NEON MAINS TESTER: SCREWDRIVERS, 5/-.
CORED SOLDER RADIOGRADE, 4d. yd. 1lb. 2/6.
PAXOLIN 1/16in. × 8in. × 10in., 1/6. ION TRAPS 5/-.

AMERICAN MAGNETIC RECORDING TAPE FERRODYNAMICS "BRAND FIVE"

5in. 600 feet	16/-	MYLAR DUPONT	
6in. 900 feet	18/6	Super High Fidelity	
5½in. 1200 feet	23/6	Double Play	
7in. 1200 feet	25/-	5in. 1200 feet	37/6
7in. 1800 feet	35/-	7in. 2400 feet	60/-

Illustrated leaflet S.A.E.

RECTIFIERS, RM1, 5/-; RM2, 6/-; RM3, 8/-; RM4, 16/-; RM5, 20/-; RC31 27/6; 14A86, 17/6; 14A100, 21/-.
MINIATURE CONTACT COOLED RECTIFIERS. 250 v. 50 mA., 7/6; 60 mA., 8/6; 85 mA., 9/6; 200 mA., 21/-; 300 mA., 27/6; Full Wave 250 v. 120 mA., 15/-.
COILS. Wearite "P" type 3/- each. Osmor Midget "Q" type adj. dust core from 4/- each. All ranges.
TELETRON. L. and M. T.R.F. with reaction, 3/6.
FERRITE ROD AERIALS. M.W., 8/9; M. & L., 12/6.
T.R.F. COILS. A/HF, 7/- pair. H.F. CHOKES, 2/6.

JASON F.M. TUNER COIL SET, £9/-. H.F. coil aerial coil. Oscillator coil two I.F. transformers, 10.7 Mc/s., Detector transformer and heater chokes. Circuit and component book using four 6AM6. 2/6. Complete kit FMT1 with Jason Calibrated dial and 4 valves. £6/5/-. With new Jason Cabinet. FMT2. £2 extra.

CONDENSERS. New Stock. .001 mfd. 7kV. T.C.C. 5/6. 20 kV., 9/6. .1 mfd. 7kV. 9/6. 100pf. to 500 pf. Micas, 6d Tubular 500 v. 0.001 to 0.05 mfd., 9d.; 0.1, 1/-; 0.25, 1/6; 0.5. 1/9: 0.1/350 v., 9d.; 0.1/1,000 v., 1/9: 0.1 mfd. 2,000 v., 3/6; 0.001 mfd., 2,000 v., 1/9.
CERAMIC CONDS. 500 v. 0.3 pf. to 0.01 mfd., 9d.
SILVER MICA CONDENSERS. 10% 5 pf. to 500 pf., 1/-: 600 pf. to 3,000 pf., 1/3.
CLOSE TOLERANCE (1 pf.) 1.5 pf. to 47 pf., 1/6. DITTO 1% 50 pf. to 815 pf., 1/9; 1,000 pf. to 2,000 pf., 2/-.
TRIMMERS. Ceramic 30, 50, 70 pf., 9d., 100 pf., 150 pf. 1/3. 250 pf., 1/6. 600 pf. 750 pf., 1/9. Phillips, 1/- ea.

NEW ELECTROLYTICS. FAMOUS MAKES

TUBULAR		TUBULAR		CAN TYPES	
1/350 v.	2/-	50/350 v.	5/6	8/500 v.	3/-
2/350 v.	2/3	100/25 v.	3/-	16/500 v.	4/-
4/450 v.	2/3	250/25 v.	3/-	32/350 v.	4/-
8/450 v.	2/3	500/12 v.	3/-	100/270 v.	5/6
8/500 v.	2/9	8+8/450 v.	3/6	2,500/3 v.	4/-
16/450 v.	3/-	8+8/500 v.	5/-	5,000/6 v.	5/-
16/500 v.	4/-	8+16/450 v.	3/9	8+16/500 v.	7/-
32/450 v.	3/9	8+16/500 v.	5/6	32+32/450 v.	6/-
25/25 v.	1/9	16+16/450 v.	4/3	50+50/350 v.	7/-
50/25 v.	2/-	16+16/500	6/-	64+120/350 v.	11/6
50/50 v.	2/-	32+32/350 v.	4/6	100+200/275v.	12/6

FULL WAVE BRIDGE SELENIUM RECTIFIERS. 2.6 or 12 v 1½ amp., 8/9; 2 a., 11/3; 4 a., 17/6: 6 a., 22/6.
CHARGER TRANSFORMERS. Tapped input 200/250 v for charging at 2, 6 or 12 v., 1½ a., 15/6; 2 a., 17/6; 4 a., 22/6
Charger circuit free. AMPMETERS, 4 a., and 5 a., 13/6.

NEW and boxed VALVES 90 day guarantee

1R5	7/6	6L6G	10/6	EA50	1/6	EY51	9/6
1S5	7/6	6N7M	6/6	EABC80	8/6	EY86	10/-
1T4	6/-	6Q7G	7/6	EB91	6/-	HABC80	12/6
2X2	3/6	6SA7M	6/-	EBC33	8/6	HVR2A	6/6
3S4	7/6	6SJ7M	6/6	EBC41	8/6	MU14	9/-
3V4	7/6	6SN7	6/6	EBF80	10/-	P61	3/6
5U4	7/6	6V6G	6/6	ECC84	9/6	PCC84	9/6
5Y3	7/6	6X4	7/6	ECF80	9/6	PCF80	9/6
5Z4	9/6	6X5	6/6	ECH42	10/6	PCL82	11/6
6AM6	5/-	12A6	7/6	ECL80	10/6	PEN25	6/6
6BE6	7/6	12AT7	8/-	ECL82	10/6	PL82	10/6
6BH6	9/6	12AU7	8/-	EF39	5/6	PY80	7/6
6BW6	9/6	12AX7	8/-	EF41	9/6	PY81	9/6
6D6	6/-	12BA6	8/6	EF50	5/6	PY82	7/6
6FG6	7/6	12BE6	8/6	EF80	8/-	SP61	3/6
6H6GT	3/6	12K7	6/6	EF86	14/6	UBC41	9/6
6J5	5/6	12Q7	6/6	EF92	5/6	UCH42	9/6
6J6	5/6	35L6	9/6	EL32	5/-	UF41	9/6
6J7G	6/6	35Z4	7/6	EL41	9/6	UL41	9/6
6K6GT	6/6	80	9/6	EL84	8/6	UY41	8/-
6K7G	5/-	807	5/6	EZ40	7/6	U22	8/-
6K8G	7/6	954	1/6	EZ80	7/6	U52	7/6

A MERRY CHRISTMAS TO ALL READERS OF "WIRELESS WORLD"

RADIO COMPONENT SPECIALISTS

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337 WHITEHORSE RD.
WEST CROYDON
THO 1665 Buses 133 or 68

POSTAL SERVICE 1/-, OVER £2 FREE. C.O.D. 1/6. (EXPORT C.W.O. POST EXTRA.) Wed. 1 p.m.

PRECISION WIDE RANGE SIGNAL GENERATOR

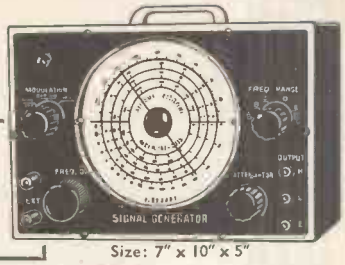
MODEL SWO-300 150 Kc/s-300 Mc/s

The Model SWO-300 is an outstanding instrument specially designed to cover the wide frequency range from 150 kc/s-300 Mc/s, which covers all the requirements of equipment in general use.

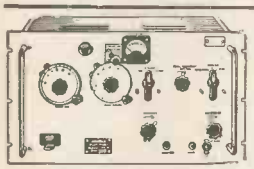
SPECIFICATION:—

- FREQUENCY RANGE: 150 kc/s-150 Mc/s on fundamentals (6 bands). 150 Mc/s–300 Mc/s on harmonics.
- CALIBRATION ACCURACY: within ±1 per cent.
- MODULATION: Internal and external.
- ATTENUATION: To —40 db.
- OUTPUT: Facilities for high and low.
- POWER SUPPLY: Internal 230 v. A.C.

ONLY
£14.19.6
P. & P. 5/6
FULLY GUARANTEED



Size: 7" x 10" x 5"



V.H.F. COMMUNICATION RECEIVER 1392

15 VALVE SUPERHET

Frequency Range 95-150 Mc/s. (2 to 3 metres)

Gives reception of Police, Aircraft and Amateur transmissions.
Valve line up: 1st and 2nd R.F. Amp. VR.136 (EF.54), 1st Local Oscillator; VR.65 (SP.61), 2 Oscillator Multipliers; VR.136 (EF.54); 3 I.F. Amp.; VR.53 (EF.39); A.G.C. 6Q7; Output 6J5; Muting VR.92 (EA.50); Noise Limiter VR.92 (EA.50); B.F.O. 6J7; Mixer VR.136 (EF.54); De Mod. 6Q7. Slow motion tuning, normally crystal controlled, or tunable over 95-150 Mc/s. Power supply required: 240-250 volts at 80 mA., 6.3 volts at 4 amps. Size 19in. x 10in. x 10in. Standard Rack Mounting.

ONLY
£6.5.0
CARRIAGE 15/-

R.F. UNITS

Undoubtedly the most useful Govt. surplus units ever released. The R.F. units will extend the frequency range of your receiver to enable you to receive, amateur, TV and VHF stations.

R.F.24	20-30 Mc/s. Switched tuning	**22/6**
R.F.25	40-50 Mc/s. Switched tuning	**8/6**
R.F.27	65-85 Mc/s. Variable tuning	**29/6**

Circuits supplied. P. & P. 3/6 on each.

NEW! TRANSISTOR RADIOS *With Miniature Speaker*

Gives reception over the entire broadcast band. Each kit is supplied with all latest miniature parts including ★ two transistors ★ ferrite rod ★ speaker ★ coloured plastic case ★ step by step illustrated instructions. 4 x 3 x ¾in.
ONLY 27/6 P. & P. 1/6. Battery 1/- ex.

NEW!

SUPER MINIATURE EARPHONE FOR TRANSISTOR CIRCUITS

Here is a really sensitive dynamic earphone of exceptionally fine quality. This lightweight miniature earpiece is convenient and comfortable to wear. The practically invisible core is connected to the earphone. Provides clear reproduction of music as well as speech. Fully Guaranteed and complete with transparent ear insert, 3 feet cord, subminiature plug and socket.
Model CR.5 Crystal Earpiece, high imp., 12/6. Post 1/-.
Model MR-4 Magnetic Earpiece, low imp. 10/6. Post 1/-.

R.C.A. COMMUNICATION RECEIVER AR-88D

Undoubtedly the finest communication receiver ever produced for service and laboratory use. Now Relda's exclusive purchase enables you to obtain this Rolls-Royce of communication receivers at the lowest price ever offered.

SPECIFICATION:
Range: 540 kc/s to 32 Mc/s in 6 bands.
Power Supply: 110/260 v. A.C.
Power Output: 2.5 W into 2.5 or 600 ohm line or H.I. Headphones.
Sensitivity: From 15 to 2.5 uv per 500 mW.
Image Ratio: From 1,000,000 at 60 kc/s to 200 at 28 Mc/s.
Circuit: Two R.F. stages (6SG7); Oscillator (6J5); Frequency Changer (6SA7); Three I.F. stages (6SJ7); A.V.C./Detector (6H6); Noise Limiter (6H6); Audio Amplifier (6SJ7); Power Output (6K6); B.F.O. (6J5); Voltage Regulator (VR-150); Rectifier (5Y3); I.F. —455 kc/s.
Size: 19¼ x 11 x 19½in.

PRICE FULLY GUARANTEED ONLY
£39.10.0
Carriage 50/-.

Model AR-88 L.F. 73–550 kc/s and 1.48–30.5 Mc/s. **ONLY £37/10/-.** Carriage 50/-.

OSCILLOSCOPE

MODEL 74

This basic scope represents one of the finest buys we have ever made! Contains Brilliance, Focus, Gain and 2-speed time base controls. Separate X plate terminals. Signal generator modulated at 2 freqs. over 150–255 Mc/s. Complete with 12 valves, VCR 139A tube, internal A.C. power pack and complete circuit and technical details.

ONLY 97'6 Carr. 12/6

VARIABLE TRANSFORMERS

● Input Voltage 230 v. continuously variable output from 0-260 v. ● GOOD REGULATION. Output voltage is substantially independent of load. ● SMOOTH CONTROL. Can be set closely to any output voltage within its range. ● HIGH EFFICIENCY. Very low losses under all load conditions. ● LONG LIFE. The same as that of any standard fixed-ratio power transformer when operated at rated loads. ● SMALL SIZE. Smaller than any other type of control of equal power rating. ● LINEAR OUTPUT VOLTAGE. Continuously adjustable from zero to 30% above line voltage by a 320-degree rotation of the knob. The dial is calibrated to read directly in output voltage at rated line voltge. ● DIRECT-READING DIALS. All models are supplied with reversible direct-reading dials. Large white figures, easy to read at a distance. ● MODERATE TEMPERATURE RISE. Less than 50 degrees C. for continuous use. ● ADVANCED MECHANICAL DESIGN. Rugged construction—no delicate parts—protected with a strong, iron cover.
ALL FULLY GUARANTEED. DELIVERY EX-STOCK.

MODEL B.10
Current rating 10 amps.
£18.5.0

MODEL B.20
Current rating 20 amps.
£32.10.0

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BARGAIN OFFERS *for the Constructor!*

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Manufacturers' brand new, current production offer. Latest 5-valve circuit based on Mullard's famous design. Magic eye level indicator. Volume and tone controls. T.C.C. printed circuit already wired. Only power pack and controls to assemble and wire. Valves EF86, ECC83, EL84, EM84 & EZ80. A sensitive quality recorder at Special Unit Prices.

Wired printed circuit, power pack components, controls and knobs, etc. P. & P. 2/6 ..... £5 15 0

Set of 5 valves, as above. P. & P. 1/- £2 5 0

B.S.R. Monardeck Tape Unit. P. & P. 4/6 ..... £8 19 6

Bargain reduction for complete kit. Carr. 5/- £16 10 0

Attractive two-tone Cabinet and 9in. x 5in. speaker to house above at special discount price. P. & P. 4/6 ..... £3 5 0

Illustrated Handbook with full details. Post free 2 6

Collaro Studio Tape Deck can be supplied with modified circuit as alternative for approx. (extra) £5 10 0

RECORD PLAYER BARGAINS Latest 4-speed models

NEW RELEASE by E.M.I.—4 speed Single Player Unit fitted with latest stereo and monaural xtal cartridge and dual sapphire styli. Auto stop and start. A fidelity unit and bargain buy at only £6/19/6, carr. & ins. 3/6.

SINGLE PLAYERS. B.S.R. (TU9) 90/-; COLLARO JUNIOR studio P.U. £4/10/-. AUTOCHANGERS. B.S.R. (UA8), £6/19/6; UA8 STEREO £7/19/6. B.S.R. (UA14) latest model, £7/19/6. COLLARO CONQUEST, £7/19/6. COLLARO CONTINENTAL £3/19/6

BARGAINS

	GARRARD PLAYER UNITS
SINGLE PLAYERS	
Model 4SP	£6/17/6. Carr. 3/6.
Model TA Mk. 3.	£7/19/6. Carr. 3/6.
Model 4HF.	£18. Carr. 3/6.
AUTOCHANGERS. Model RC 210, With plug-in GC8 Head. 10 gns. Carr. 4/6.	
Transcription Auto Changer Model "A" just realeased	£18/19/6. Carr. 5/-.

AUTO CHANGER RECORD PLAYER KIT

A.C. Supply 200v.-250v. Attractive 2-tone cabinet—famous B.S.R. Monarch 4-speed, full mixer, 10-record gram unit. Ful-fi xtal pick-up with dual styli for 8td. L.P. recordings. 2-valve amplifier with quality neg. feedback circuit, volume and tone controls. Fully isolated from mains by double-wound transformer, NOT the line chassis type as often offered in cheap commercial models.

A recommended buy while stocks last! Ready wired 2-valve Amplifier, complete with 6in. high flux speaker.

£3/19/6, P. & P. 2/6

Two-tone Cabinet 18in. x 13in. x 8in.

£3/3/-, P. & P. 3/6

B.S.R. Monarch U.A.8 (160 v. model).

£5/19/6, P. & P. 4/6

Complete 3 unit kit at special Autumn Bargain price. £12/12/6, Carr. 7/6

Simple assembly, a screwdriver only required.

TRANSISTORS BVA—1st Grade *New Reduced Prices*

MAZDA	MULLARD	G.E.C.
XA101 14/6	OC70 9/6	GET114 9/6
XA102 16/6	OC71 12/6	GET115 12/6
XA103 15/-	OCT72 15/-	Newmarket
XA104 18/-	OC44 23/6	"Goldtop"
XB102 10/-	OC45 21/-	V15/10P
XC101 10/6		15/-

Germanium Diodes OA70 2/9; OA81 3/6; GEX34 4/-.

VALVES

NEW BOXED			ALL GUARANTEED
1T4	6/-	EABC80	8/6
1R5, 1S5	7/6	ECC84	9/6
3S4, 3V4	7/6	ECF80	9/6
5Z4	9/-	ECL82	10/6
6K7	5/-	ECL80	10/6
6K8	7/6	EF80	8/-
6Q7	7/6	EF86	12/6
6V6	6/6	EF91	5/-
DAF96	9/-	EL41	9/6
DF96	9/-	EL84	8/6
DK96	9/-	EY51	9/6
DL96	9/-	EY86	10/-
EZ81	7/6		
MU14	9/-		
PCC84	9/6		
PCF80	9/6		
PCL83	12/6		
PL81	12/6		
PL82	9/6		
PL83	10/6		
PY80	7/6		
PY81	9/6		
PY82	7/6		
U25	12/6		

SPECIAL PRICE PER SET 1R5, 1T4, 1S5 or 3S4 or 3V4, 25/- DK96, DF96, DAF96, DL96, 35/- 6K8, 6K7, 6Q7, 6V6, 5Z4 or 6X5, 32/6.

JASON FM TUNER UNITS (87-105 Mcs)

Designer-approved kits of parts for these quality and highly popular tuners available as follows:—

STANDARD MODEL (FMT)—as previously extensively advertised. COMPLETE KIT, 5 gns., p. & p. 2/6. Set of 4 spec. valves, 20/-.

LATEST MODEL (FMT2)—attractively presented shelf mounting unit in enclosed Metal Cabinet with Built-in Power Supply. COMPLETE KIT, £7, p. & p. 3/6. Set of 5 spec. valves, 37/6.

MODEL JTV2. Self-powered Switch Tuned B1-B2-B3 AM/FM Unit. 5 preset stations, AFC and AGC circuits. Complete Kit incl. ready-built and valved Turret Tuner, £12/19/6. p. & p. 3/6. 4 spec. valves, 32/6 extra.

MERCURY 2 similar to JTV2 less power pack. Complete Kit inc. ready-built turret unit 10 gns, p. & p. 2/6. 4 spec. valves 25/-.

NEW JASON COMPREHENSIVE F.M. HANDBOOK, 2/6 post free. 48hr. Alignment Service, 7/6, p. & p. 3/6.

MAINS TRANS. AND QUALITY OUTPUT TRANS. Mfd. in our own workshops to top grade spec. Fully interleaved and impregnated. Enquiries welcomed for small production runs. prototypes or individual jobs.

RECORDING TAPE BARGAINS

EMI 1st grade. Brand new sealed boxes.

Standard		Long Play	
3in., 175ft.	7/-	250ft.	9/-
5in., 600ft.	19/-	850ft.	25/-
5½in., 850ft.	25/-	1,200ft.	31/6
7in., 1,200ft.	31/5	1,800ft.	45/-

SPARE REELS: Emitape, new, boxed: 3in. 3/-, 5in. 3/8, 5½in. 4/-, 7in. 4/6.

SPECIAL PURCHASE. Famous manufacturers, 1st grade tape, in sealed white boxes.

Standard		Long Play	
5in., 600ft.	15/-	850ft.	19/6
5½in., 850ft.	16/6	1,200ft.	22/6
7in., 1,200ft.	21/-	1,800ft.	32/6

Plastic Tape Reels, special offer. Manufacturers' surplus. 3in. 2/9, 5in. 3/-, 5½in. 3/3, 7in. 3/6.

2 WAVEBAND CAR RADIO KIT

12v. operation Med. & Long Waves

Recommended Buy

Modern development of the famous Brimar Hybrid vibratorless car radio circuit. Five latest type Brimar low voltage valves and power transistor. R.F. stage and permeability prealigned Cyldon Tuner Unit provide extremely good sensitivity and signal noise ratio. Printed circuit for easy construction and 7 × 4in. elliptical speaker for fidelity output. Self-contained in neat metal cabinet 8 × 7 × 2½in., with attractive calibrated dial. Speaker and power transistor stage mounted separately approx. 8 × 5 × 3in.

Complete Kit Bargain Price P&P £12.19.6 3/6.

Instruction booklet and parts list available. 3/6 post free.

TRANSISTOR PORTABLE

Famous manufacturer's 6 × 1 design based on Mullard and G.E.C. developments. Printed circuit, 6BVA 1st grade transistors, XA102 XA101 (2), OA70, XB103, XC101 (2) or equivalents. Quality components only supplied to ensure best results at attractive price.

Set of 6 BVA Transistors and Diode. P. & P. 6d. ... 70/-

Printed Circuit, I.F.'s (3), Osc. coil, Driver Trans. and Ferrite rod aerial. P. & P. 1/6 51/6

Resistors, Condensers, Twin Gang and Volume control. P. & P. 1/6 ..... 37/6

7in. × 4in. Quality 35 ohm matching Speaker. P. & P. 1/6 ..... 25/-

Or

Complete Kit at special offer ONLY (post free) ..... £8/19/6.

Handbook and Circuit details, post free 2/-

KNOBS. Modern Continental types, walnut and ivory. 1¼in. dia. with GOLD RING 1/- ea. Ditto with GOLD CENTRE 1/3 ea. 1in. dia. with GOLD RING 9d. ea. Ditto with GOLD CENTRE 10d. ea. LARGE STOCKS—SEND YOUR ENQUIRIES.

CRT HTR ISOLATION TRANSFORMERS

New improved types, low capacity, small size and tag terminated, A.C. 200/250 v. Secondaries Nil, +25%, +50% BOOST for 2 v., 4 v., 6.3 v., 10.5 v., 12 v. or 13 v. tubes. 12/6 each. P. & P. 1/6.

COAX 80 ohm CABLE

Now only 6d. a yard.

High grade low loss Cellular Air Spaced Polythene—¼in. diam.—Famous mfr.

BARGAIN PRICES—SPECIAL LENGTHS.

20 yds. ..... 9/- P. & P. 1/6
40 yds. ..... 17/6 P. & P. 2/-
60 yds. ..... 25/- P. & P. 3/-

Coax Plugs, 1/-; Coax Sockets, 1/-; Couplers, 1/3; Cable End Sockets, 1/6 Outlet Boxes, 4/6.

RE-GUNNED TV TUBES NEW REDUCED PRICES

. . . and now 12 months' guarantee!

All tubes rebuilt with new heater, cathode and gun assembly — reconditioned virtually as new.

12in. £5, 14in. £5/10/-, 17in. £6, etc.

10/- part exchange allowance on old tube

Carr. and ins. 10/-. Comprehensive stocks—quick delivery.

CONDENSERS—Silver Mica. All pref. values, 2 pf. to 1,000 pf., 6d. each. Ditto ceramics 9d. each. Tubulars 450 v. T.C.C. etc., .001 mfd.-.01 and .1/350v., 9d. each. .02-.1/500v., 1/- each. .25 Hunts 1/6. .5 T.C.C. 1/9. .001 6kv. 5/6. .001 20 kv. 9/6.

RESISTORS—FULL RANGE 10 ohms—10 megohms 20%, ½ w. and ¼ w. 3d., ½ w. 5d. (Midget type modern rating), 1 w. 6d., 2 w. 9d., 10% Hi-Stab, ½ w., 5d., ¼ w., 7d., 5% ½ w., 9d., 1% HI-STAB, ½ w., 1/6 (10-100 ohms 2/-).

PRE-SET W/W POTS. T/V type, 25 ohms—50 K ohms 3/-. 50K—2 Meg. (Carbon 3/-). SPEAKER FRET—Expanded Bronze anodised metal 8 × 8in., 2/3; 12 × 8in., 3/-; 12 × 12in., 4/6; 12 × 16in., 6/-; 24 × 12in. 9/-; 36 × 12in., 13/6, etc., etc.

TYGAN FRET (Contemporary pat.). 12 × 12in. 2/-; 12 × 18in., 3/-; 12 × 24in. 4/-; etc.

LOUDSPEAKERS—P.M. 3 ohms, 2½in., Elac, 17/6; 3½in. Goodmans 18/6; 5in. Rola, 17/6; 6in. Elac, 18/6; 7 × 4in. Goodmans Elliptical, 18/6; 8in. Rola, 20/-; 10in. R. and A., 25/-; 10in. W.B.-HF1012, 95/-; 12in. Plessey 15 ohms with 6/4in. Tweeter and Cross Over Filter, 97/6.

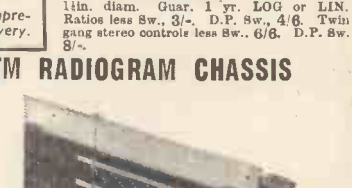
Electrolytics All Types New Stock

TUBULAR		CAN TYPES	
25/25 v. 50/12 v.	1/9	8+8/450 v.	4/6
50/50 v. 100/25v.	2/-	32+32/275 v.	4/6
8/450 v. 4/350 v.	2/3	50+50/350 v.	6/-
16+16/450 v.	5/6	60+250/275 v.	12/3
32+32/450 v.	6/6	100+200/275 v.	12/6

Comprehensive range in stock.

VOLUME CONTROLS—5K—2 Megohms. ALL LONG SPINDLES, MIDGET TYPE. 1¼in. diam. Guar. 1 yr. LOG or LIN. Ratios less Sw., 3/-. D.P. Sw., 4/6. Twin gang stereo controls less Sw., 6/6. D.P. Sw. 8/-.

7 VALVE AM/FM RADIOGRAM CHASSIS



Valve Line-up: ECC85, ECH81, EF89, EABC80, EL84, EM81, EZ80.

Three Waveband and Switched Gram positions. Med. 200-500 m., Long 1,000-2,000 m., VHF/FM 88-95 Mc/s. Philips Cont nental Tuning insert with permeability tuning on FM and combined AM/FM IF transformers, 460 Kc/s. and 10.7 Mc/s. Dust core tuning all coils. Latest circuitry including AVC and Neg. Feedback. Three watt output. Sensitivity and reproduction of a very high standard. Chassis size 13½ × 6¼in. Height 7¼in. Edge illuminated glass dial 11½ × 3½in. Vertical pointer. Horizontal station names. Gold on brown background. A.C. 200/250 v. operation. Magic-eye tuning.

Aligned and tested ready for use. **£13 . 10 . 0** *Carr. & Ins. 5/-.*

Complete with 4 Knobs—walnut or ivory to choice. Indoor FM aerial 3/6 extra. Three ohm P.M. speaker only required. Recommended quality speakers.

10in. Rola (Heavy Duty) 30/-

8in. Goodmans special cone 21/6

Post & Pkg. 1/6.

As previously announced fresh supplies are now being received, but we regret some slight delay may be experienced in fulfilling orders for this popular item.

ONLY A FEW ITEMS ARE LISTED FROM OUR COMPREHENSIVE STOCK. WRITE NOW FOR FULL BARGAIN LISTS, 3d.

Terms: C.W.O. or C.O.D., post and packing up to ½lb. 7d.; 1lb. 1/1; 3lb. 1/6; 5lb. 2/-; 10lb. 2/9.

T S RADIO COMPONENT SPECIALISTS

70 BRIGSTOCK RD., THORNTON HEATH, SURREY

Established 1946.

Tel.: THO 2188. Hours: 9 a.m.—6 p.m. 1 p.m. Wednesday.

GEE BROS. (RADIO) LTD.

15 LITTLE NEWPORT STREET, LONDON, W.C.2. *GER. 6794/1453*

ADJOINING LEICESTER SQ. TUBE STATION—Open 9-6 Weekdays. 9-1 Sat.

S.T.C. SELENIUM METAL RECTIFIERS. F/B, FOR BATTERY CHARGERS, ETC.

6 or 12 v. 1 amp.	5/-;	24 v. 1 amp.	10/-;
12 v. 2 amp.	7/6;	24 v. 2 amp.	15/-;
12 v. 2½ amp.	12/6;	24 v. 3 amp.	25/-;
12 v. 4 amp.	15/-;	24 v. 4 amp.	30/-;
12 v. 6 amp.	20/-;	24 v. 6 amp.	32/6;
12 v. 10 amp.	35/-;	24 v. 10 amp.	70/-;

NEW AND UNUSED ACCUMULATORS

12 v. 25 A.H. (as illus.) 45/-. Carr. 7/6. (Ideal for use with our Amplifier in centre column).

2 v. 100 A.H. 75 actual (ex-Govt.) with carrying handle. Size 6½ x 6½ x 3½in., 15/- each. Carr. 3/6.

2 v. 16 A.H., as above. 7½ x 4 x 2in., 5/- each. P. & P. 2/-.

6 for 24/-. P. & P. 10/-.

2 v. 14 A.H., as above (less handle). 7 x 2½ x 2½in., 5/- each. P. & P. 2/-.

TRANSFORMERS

POTTED C CORE

Pri. 230 v. 50 c/s.
Sec.: 450-0-450 v. 220 mA. 5 v. 3 amps., 6.3 v. 5 amps., 6.3 v. 3 amps. **£2/10/-.** Carr. 5/-.

Pri.: 230 v. 50 c/s. E.S.
Sec.: 500-0-500 v. 500 mA. 6.3 v. 500 mA., 6.3 v. 5 amps., 5 v. 6 amps. **£3/10/-.** Carr. 5/-.

Pri.: 230 v. 50 c/s.
Sec.: 6.8 v. 5 amps., 6.3 v. 1 amp., 6.3 v. 3 amps., 6.3 v. 1.5 amps., 6.3 v. 2 amps., 6.3 v. 3 amps., 6.3 v. 4 amps. **£1/12/6.** Carr. 5/-.

MAINS ISOLATING TRANSFORMER (Gresham). Pri. 230/250 v. Secs. 240-0-240 v. 1.5 amps., 5 v. 12.5 amps. Potted. Size 7in. x 7½in. x 10½in. Weight 50 lb. Ideal for obtaining TWO ISOLATED 240 v. lines at 360 watts each. Perfect condition. **80/-.** Carr. 10/-.

L.T. TRANSFORMERS for Battery Chargers etc. All Pri.: 200/250 v. Tapped 50 cycles.
Type 048B. Sec. 24, 30, 36 v. 6 amps. 4 x 4 x 4in. **£2/9/6.** Carr. 3/6.
Type 066A. Sec. 18, 24, 30 ,36 v. 8 amps. 4 x 4 x 5in. **£3/19/6.** Carr. 3/6.
Type 053A. Sec. 12, 24, 30 v. 10 amps. 4 x 5 x 5in. **£4/4/-.** Carr. 3/6.

AUTO TRANSFORMERS. 0-110, 205, 225, 245 v. Fully shrouded. Terminal block connectors.
Type 063A. 500 w., 4 x 5 x 5in. **£3/7/6.** Carr. 3/6.
Type 064A. 750 w. 4 x 6 x 5in. **£3/17/6.** Carr. 3/6.
Type 065A. 1000 w. 4 x 7 x 5in. **£4/17/6.** Carr. 5/-.

3 kV/A. AUTO TRANSFORMER. 250/110 v. 50 cycles (fully tapped primary and secondary). Capable of 25% over actual rating. Brand new and unused, **£12/10/-.** Carr. 20/-. Also 6 kV/A. as above. **£18.** Carr. 20/-.

20 kV/A. AUTO-TRANSFORMER. 230/115 v. 50-60 cycles, by Jefferies Transformer Co., U.S.A. Perfect condition, **£20.** Carr. 20/-.

CONSTANT VOLTAGE TRANSFORMER 190-260 v. primary, sec. 115 v. at 1¼ kV/A. (listed at 2 kV/A). Brand new and unused. **£25** or **£45** per pair. Carr. 10/- each.

E.H.T. TRANSFORMER. 8,000-0-8,000 at 400 mA. Primary 230 v. 50 cycles. Oil filled. New and in original crates. **£25.** Carr. 10/-.

E.H.T. TRANSFORMER. 1,800-0-1,800 at 1 kV/A. 230 v 50 cycles primary. Fully tropicalised. New and boxed. **£6/10/-.** Carr. 10/-.

E.H.T. TRANSFORMER. 1,100-0-1,100 at 250 mA. plus 4 v. L.T. Pri. 200/250 v. at 50 cycles. **£5.** Carr. 10/-.

CONDENSER, oil filled. 240 mfd. 230 v. A.C. or 600 v. D.C. Made in U.S.A. Size 21in. x 5¾in. x 9in. Brand new in original cases. **£7/10/-.** Carr. 5/-.

ROTARY CONVERTER. 24 v. D.C. input. 230 v. A.C. output at 250 watts. Complete with starting switch. New and unused. **£15.** Carr. 7/6.

ROTARY CONVERTER. 24 v. D.C. to 230 v. A.C. 50 cycles, 150 watts. Brand new and unused. **£8/10/-.** Carr. 7/6. Ditto, 100 watts **£6/9/6.** Carr. 7/6.

ROTARY CONVERTER. Ex-Govt. 12 v. D.C. input, 230 v. A.C. output 50 cycles at 135 watts. Complete in carrying case with lid. Voltage control, sliding resistance, mains switch and 0-300 v. A.C. flush meter. In good condition. **£10.** Carr. 10/-.

Motor only, without case, etc. Brand new and unused. **£8/10/-.** Carr. 5/-.

BAKERS 'SELHURST' SPEAKERS

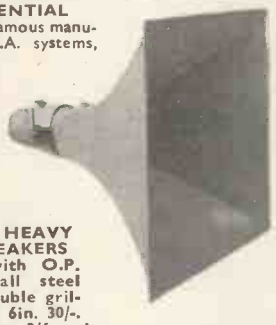
ALL BRAND NEW

SPECIAL NEW ARRIVAL!
"15in. VISCOUNT AUDITORIUM"
15 ohms at 400 c.p.s., 35 watts. Flux density 18,000.
OUR PRICE £15.

"12in. P.M.," 15 ohms, 15 watts, 30-14,000 c.p.s. Our price **£4/10/-.**
"AUDITORIUM" 12in., 15 ohms, 12 watts. 35-16,000 c.p.s. Flux density 14,500. OUR PRICE **£7/10/-.**
"SUPER HI-FI 25" 12in., 15 ohms, 25 watts 25-20,000 c.p.s. Flux density 17,600. OUR PRICE **£9/9/-.**
Full descriptive specification is available.

12 VOLT D.C. AMPLIFIER (Parmeko, Ardente). As new, 15 watt output with 2-EL35's in push-pull. Mike and gram. inputs, tapped output transformer, **£9/19/6.** Carr. 10/6.
(Suitable microphone for above 30/- extra.)

EXPONENTIAL HORNS by famous manufacturer of P.A. systems, 15 watt, 25 in. long, 20in. square flare 15 ohms speech coil. (Tannoy) Good condition, **£7/10/-.** Carr. 10/-.



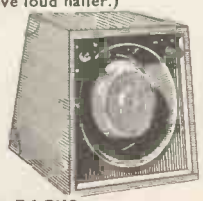
NEW P.M. HEAVY DUTY SPEAKERS
Complete with O.P. trans., in all steel blue-grey double grilled cabinet. 6in. 30/-. 8in. 32/6. Carr. 3/6 each.

10in. SPEAKER in wooden cabinet, size approx. 14 x 16 x 8in. with padded interior and volume control, 50/-. Carr. 3/6.

RE-ENTRANT LOUD HAILERS (Ex-Govt.) Heavy duty 20 watts all-metal 15 ohms. Diameter 15in., length 15in. (approx.) good cond. **£6/10/-.** Carr. 10/-. Ditto. Brand new, **£8.** Carr. 10/-.

HEAVY DUTY ALL STEEL TRIPOD STANDS (as illus. Sept. issue). Adjustable every 6in. to approx. 9ft. 6in. when fully extended. (Folds up to only 4ft. 6in. for storage.) Suitable for outdoor speakers, public address systems, flood-lighting, etc. OUR PRICE **£3/10/-.** Carr. 5/-. (Ideal stand for the above loud hailer.)

TRUVOX/TANNOY LOUD-HAILERS
With 180 ohm line transformer and condenser. Impedance 7½ ohms, handling capacity 8 watts. Complete in slope-front wooden case. Brand new **25/-.** Carr. 4/6.



G.P.O. RACKS
19in. Heavy duty all steel Standard drilling.
5ft. 6in. angle uprights. **£3/10/-.** Carr. 15/-.
6ft. channel uprights. **£5.** Carr. 15/-.
7ft. channel uprights. **£6.** Carr. 15/-.

AR88-D RECEIVER.
Frequency 540 kc/s-32 Mc/s £50 carr. 20/-, also model L.F. available 75/550 kc/s, 1·5/30 Mc/s £45, carr. 20/-, both mint condition and overhauled for the Ministry to the highest specifications. Limited quantity only.

QUALITY TEST EQUIPMENT

RECORD MEGGERS. 500 v. insulation tester, 0-20 megohms. In leather case. Perfect order. **£10.**

EVERSHED AND VIGNOLES MEGGER CIRCUIT TESTER (low reading ohm meter). 2 ranges 0-3, 0-30 ohms. The perfect meter for continuity and polarity testing,c omplete with test leads and ready to use. Brand new. Only **£4/17/6.** P. & P. 3/-.

BRIDGE MEGGERS. Evershed and Vignoles. Series 2 in perfect condition. 250 v. **£22.** Carr. paid. Leather case available at 20/- extra.

MARCONI SIGNAL GENERATOR. TYPE TF517-F/I. Covering 10-18 Mc/s. 33-58 Mc/s. 150-300 Mc/s. In very good condition. Complete with full technical data and instructions. Unrepeatable at only **£12/10/-.** Carr. 20/-.

BRAND NEW CRYSTAL CALIBRATOR No. 10. (Battery powered 1.4 v. valves.) Complete with full working instructions, circuit diagram, carrying haversack, connecting lead and spare valves. Frequency range: 1.5 to 10 Mc/s. (nominal) but can actually be used up to 30 Mc/s. Weight 5lb. Size 7 x 7½ x 4in. A miniature B.C.221 in every respect. A must for every laboratory, etc. ONLY **£4/19/6.** P. & P. 2/6.

MULLARD BRIDGE. Type GM. 4140/1. Mains operated from 100-250 v. A.C. Will test resistances from 0.1 ohm to 10 megohms and condensers from 10pf. to 10mfd. Good condition and complete with instruction booklet. **£6/19/6.** P. & P. 2/6.

TAYLOR VALVE TESTER Model 47A. Input 200-250 v. A.C. Will test all types of English and American valves with filaments from 1.1 v. to 117 v. Perfect condition. Complete with full instruction manual, **£12/10/-.** Carr.paid. Also MODEL 45A available at **£10/10/-.**

10-LINE TELEPHONE SWITCH-BOARDS. For the complete control of 10 extensions (Tele. "F" etc.). Complete with jacks, leads and operator's hand set. Good condition. **£9/19/6.** Carr. 10/6.

TELEPHONE SETS (TELE "F")
Housed in Bakelite cases, complete with built-in ringing generators and batteries. Ideal between two or more positions up to practically any distance. Tested before despatched. ONLY **70/-.** P. & P. 3/6. 2 sent for **£6/10/-.** Carr. paid.

TELEPHONE CABLE. Twin one-mile drums (Don 8), **£5.** Carr. 20/-. Single one-mile drums (Don 3), **50/-.** Carr. 7/6.

COLLARO "STUDIO" TAPE TRANSCRIPTORS. Brand new in original cartons 3 speeds. 1⅞, 3¾, 7½ i.p.s. 3 motors, digital counter, etc. Complete with 7in. spool instructions and fixings. A.C. 200/250 v. operation. **SPECIAL PRICE £12/10/-** only.
RECORDING TAPES. Super quality P.V.C. 1,800ft. L.P. 7in. spools, 30/-; 1,200ft. Std. 7in. 19/-; Empty 7in. spools 3/9 each.
Send S.A.E. for current Tape Bargain List.

A.C.-D.C. RECTIFIER POWER SUPPLY UNITS

110/230 v. A.C. 50 cycles input, 100/110 v. D.C. output max. 2½ amp. Brand new and unused. **£4/10/-.** Carr. 7/6.

230 v. A.C. 50 cycles input, 200/220 v. D.C. output at 3/4 amps. approx. Good condition. **£10.** Carr. 10/-.

200/250 v. pri., 110 v. sec. at 4 amps. max. Brand new and unused. **£8/10/-.** Carr. 10/-.

Type 67. 200/230 v. A.C. 50 cycles input, 240-0-240 v. D.C. output at 1½ amps. (Valve rectification.) With overload controls. Brand new in maker's original crates. **£10.** Carr. 10/-.

AIRBORNE TRANSMITTER RECEIVER TYPE 1986. A mobile 10-channel crystal controlled V.H.F. Tx/Rx. covering 124.5/156 Mc/s. I.F. band width 23 kc/s. Complete (less external attachments) in metal case, with all valves and 24 v. rotary power unit. Used but in first-class condition. ONLY **£8/10/-.** Carr. paid Also, complete with control box and all necessary connecting leads, **£12,** carr. paid.

HEAVY DUTY REGULATING RESISTOR. 0.25 ohm, 200 amps. Wheel control **£4/15/-.** Carr. 10/-.

DOUBLE BEAM 'SCOPE'

For D.C. & A.C. APPLICATIONS

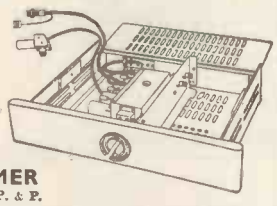
Engineered to precision standards, this high-grade instrument is made available at the lowest possible price, incorporating the essential features usually associated with luxury instruments. This "SCOPE" will appeal particularly to Service Engineers and Amateurs. A high gain, extremely stable differential Y-Amplifier (30 mV/C.M.). Provides ample sensitivity with A.C. or D.C. inputs. Especially suitable for measurement of transistor operating conditions where maintenance of D.C. levels is of paramount importance. Push-Pull X amplifier. Flyback suppression; Internal Time base Scan Waveform available for external use; pulse/output available for checking T.V. Line O/P Transformers, etc.; Provision for external X 1/P and CRT. Brightness Modulation. A.C. mains 200/250 v **£19/19/-** plus P. & P. 7/6 or 50/- deposit, plus P. & P. 7/6 and 12 monthly payments of 33/4.

FULL 12 MONTHS' GUARANTEE INCLUDING VALVES AND TUBE

ALIGNMENT ANALYSER TYPE MC12

A.C. MAINS, 200/250 volts. Provides:—"WOBBULATOR" (SWEPT FREQUENCY) OPERATION, for FM/TV alignment linear frequency sweep up to 12 Mc/s. From 400 Kc/s—80 Mc/s. CAPACITANCE MEASUREMENT. Two ranges provided 0-60 pf. and 0-120 pf. SPECIAL FACILITY enables true resonant frequency of any tuned circuit L.F. transformer, etc., to be rapidly determined. Cash price £6/19/6 and 5/- P. & P. H.P. terms 25/- deposit and 5/- P. & P. and 6 monthly payments of 21/6.

CHANNEL TUNER



Will tune to all Band I and Band III stations. BRAND NEW by famous manufacturer. Complete with P.C.C. 84 and P.C.F. 80 valves (in series) I.F. 16-19 or 33-38. Also can be modified as an aerial converter (instructions supplied).
Complete with knobs.

32/6 Plus 3/6 P. & P.

HEATER TRANSFORMER

To suit the above, 200-250 v. 6/- Plus 1/6 P. & P.

B.S.R. MONARCH UA8 with FUL-FI HEAD

4-speed plays 10 records 12in. 10in., or 7in. at 16, 33, 45 or 78 r.p.m. Intermixes 7in., 10in and 12in. records of the same speed. Has manual play position; colour brown. Dimensions: 12½in. × 10½in. Space required above baseboard 4½in., below baseboard 2½in. Fitted with Ful-Fiturnover crystal head. **£6/19/6.** Plus 5/- P. & P.

STEREO HEAD £7/19/6 Plus 5/- P. & P.

LINE E.H.T. TRANSFORMER

With built-in line and width control. 14 KV. Scan coil. 90° deflection, on ferrite yokes. Frame O.P. transformer 500 pf. 18 KV. smoothing condenser. Can be used for 14in., 17in. or 21in. tubes.

Complete with circuit diagram. **29/6** Plus 4/- P. & P.

As above, but for 625 lines **£2.10** Plus 4/- P. & P.

FOCUS MAGNET suitable for the above (state tube), 10/-. 2/6 P. & P.

MAINS TRANSFORMERS

All with tapped primaries 200-250 volts.

0-160, 180, 200 v., 60 ma., 6.3 v. 2 amps., **10/6.** 280-0-280, 80 ma., 6.3 v., 2 amp., 6.3 v., 1 amp., **10/6.** 350-0-350, 70 ma., 6.3 v. 1 amp., 6.3 v. 2 amp., **10/6.** 250-0-250, 70 ma., 6.3 v., 2 amp., **10/6.** Postage and packing on the above 3/-.

SURFACE BARRIER TRANSISTORS

type SB 305, 15 Mc/s. **7/6** each.

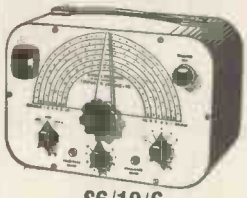
100% AUDIO TRANSISTORS

5/- each.

BATTERY RECORD PLAYER AND AMPLIFIER

Incorporating 45 r.p.m. "Starr" motor, "Acos" crystal pick-up, 3 transistor push-pull amplifier complete with transistors. Output 500 milliwatts, **49/6** plus 3/6 P. & P.

SIGNAL GENERATOR

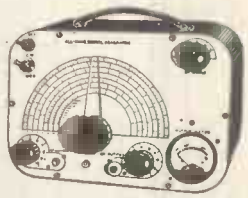


Covering 100 Kc/s.-100 Mc/s. on fundamentals and 100 Mc/s. to 200 Mc/s. on harmonics. Metal case 10in. × 6¾in. × 5¼in., grey hammer finish. Incorporating three miniature valves and Metal Rectifier. A.C. Mains 200/250 v. Internal Modulation of 400 c.p.s. to a depth of 30%. Modulated or unmodulated R.F., output continuously variable 100 millivolts C.W. and mod. switch, variable A.F. output. Incorporating magic-eye as output indicator. Accuracy plus or minus 2%.

£6/19/6

Or 25/- deposit and 6 monthly payments of 21/6. Post & Packing 5/- extra.

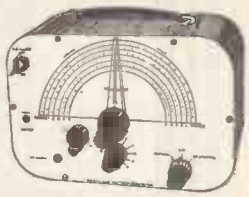
SIGNAL GENERATOR



Coverage 120 Kc/s.—230 Kc/s., 300 Kc/s.—900 Kc/s. 900 Kc/s.—2.75 Mc/s., 2.75 Mc/s.—8.5 Mc/s., 8 Mc/s.—28 Mc/s., 16 Mc/s.—56 Mc/s., 24 Mc/s., 84 Mc/s. Metal case 10in. × 6¾in. × 4¾in. Size of scale 6¼in. × 3¼in. 2 valves and rectifier A.C. mains 230-250 v. Internal modulation of 400 c.p.s. to a depth of 30 per cent. modulated or unmodulated R.F., Output continuously variable, 100 millivolts C.W. and mod. switch variable A.F. output and moving coil output meter. Grey hammer finish case and white panel. Accuracy plus or minus 2%. **£4/19/6**

Or 25/- deposit and 4 monthly payments 21/6. P. & P. 5/- extra.

SIGNAL & PATTERN GENERATOR



£6/19/6 P. & P. 5/-.

Or 25/- deposit. P. & P. 5/- and 6 monthly payments of 21/6.
Coverage 7/6 Mc/s.-210 Mc/s. in five bands, all on fundamentals slow motion tuning audio output. 8 vertical and horizontal bars, logging scale. In grey hammer finished case with carrying handle. Accuracy ±1% A.C. mains 200-250 v.

CYLDON TURRET TELETUNER

I F 34/38 Mcs. Brand new complete with biscuit for channels 2, 4, 8 & 9

less valves **10/-** plus 2/6 P. & P.
(Valves required P.C.C., 84 & P.C.F. 80.)
Pair of knobs to suit above, 3/6.

3-TRANSISTOR POCKET RADIO

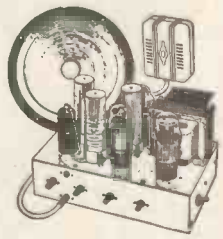
INCORPORATING MINIATURE SPEAKER
Plus GERMANIUM DIODE and PRINTED CIRCUIT
Size 3¼ x 4 x ⅞in.
Incorporating Ferrite Rod Aerial. Two Surface Barrier Transistors and one Audio. Tunable over medium and long waves.

To build yourself **39/6** Plus 1/6 P. & P.
ALL PARTS SOLD SEPARATELY.
Circuit diagram 1/6, free with kit.

All transistors guaranteed 100%

8 WATT PUSH-PULL AMPLIFIER

COMPLETE WITH CRYSTAL MIKE AND 8in. LOUDSPEAKER



A.C. mains 200/250 v. Size 10½in. × 6½in. × 2½in. Incorporating 6 valves. H.F. pen, 2 triodes, 2 output pens., and rectifier. For use with all makes and types of pick-up and mike. Negative feed-back. Two inputs, mike and gram., and controls for same. Separate controls for Bass and Treble lift. Response flat from 40 cycles to 15 Kc/s. ±2 db.; 4 db. down to 20 Kc/s. Output 8 watts at 5% total distortion. Noise level 40 db down, all bum. Output transformer tapped for 3 and 15 ohm speech coils. For use with Std. or L.P. records, mucsial instruments such as Guitars, etc.

£4.19.6 Plus P. & P 7/6.

Or £1 deposit, plus P. & P. 7/6 and 4 monthly payments of 23/-.

PORTABLE AMPLIFIER

On printed circuit for A.C. Mains 200/250 v. Size 4in. × 3in. with tone and volume control. Valves: ECL82 and EZ80, 39/6. P. & P. 2/6.

RADIO AND T.V. COMPONENTS (ACTON) LTD.

23A, ACTON HIGH STREET, LONDON, W.3

GOODS NOT DESPATCHED OUTSIDE U.K. ALL ENQUIRIES S.A.E. TERMS OF BUSINESS C.W.O.

VALVES

Brand new, individually checked and guaranteed

AC/DD	2/6	EAC91	4/6	H63	3/6	PY32	19/-	Z31	6/-	6F12	4/6	12AX7	7/-	829A	30/-
AC/P	4/6	EB34	1/6	HL23	6/-	PY81	7/-	1A3	3/6	6G6G	3/-	12C8	7/6	832	15/-
AC/P1	2/6	EB91	4/3	KBC32	5/-	PY82	8/-	1A5GT	5/-	6HA7	4/3	12E1	22/6	843	7/6
AC5PENDD	4/-	EBC33	6/-	KF35	5/-	QP21	6/-	1C5GT	7/6	6H6M	2/-	12H6	2/-	861	15/-
AC6/PEN	5/-	EBC91	4/6	K12	4/-	QP25	5/3	1D8GT	6/-	6H6GT	1/-	12K8GT	9/-	866A	10/-
AC/SP3	4/6	EC52	3/-	KT31	8/-	QQVO 6-40	45/-	1E7GT	7/6	6J5	3/6	12J5GT	3/6	872A	35/-
AL60	6/-	ECC32	4/-	KT32	8/-	QS75/20	6/9	1L4	3/9	6J7	7/6	12SC7	4/6	930	8/-
AR8	5/-	ECC81	6/6	KT33C	7/-	QS95/10	6/9	1LDS	3/6	6J5G	3/3	12SG7	6/6	954	2/-
ARDD5	2/-	ECC82	6/9	KT44	7/-	QS108/45	6/9	1R5	6/9	6J6	4/3	12SH7	4/9	956	2/-
ARP3	3/-	ECC83	7/-	KT63	6/-	QS150/15	6/9	1S5	6/-	6K6GT	6/6	12SJ7	6/-	957	2/-
ARP4	3/6	ECC84	7/9	KT66	11/-	R10	12/6	1T4	4/-	6K7G	2/3	12SK7	5/-	1619	5/-
ARP12	2/9	ECC91	4/-	KT241	9/-	REL21	25/-	2A3	8/-	6K7GT	5/3	12SL7	7/-	1625	6/-
ARP21	5/6	ECL80	9/6	KTW62	7/6	RK34	2/6	2A5	8/-	6K8G	6/6	12SR7	6/-	1626	4/6
ARP24	3/6	EF22	7/3	KTW63	6/6	RL37	3/6	2A6	7/-	6L5G	6/-	15D2	6/-	1629	4/6
ARP34	4/6	EF32	5/-	L30	4/-	SP2	4/-	2C34	2/6	6L6	9/-	15E	8/-	4120	4/-
ARTH2	7/-	EF36	3/6	LP2	3/6	SP4B	7/6	2D4A	4/-	6L6G	6/6	15R	7/6	7193	1/9
ATP4	2/9	EF37A	8/-	MH4	3/6	SP13C	4/6	2X2	4/-	6L34	4/6	30	5/-	7475	5/-
ATP7	5/6	EF39	4/6	ML4	4/-	SP41	2/6	3A4	6/-	6N7G	6/6	35T	30/-	8010AR	22/6
AU1	5/-	EF50	2/6	ML6	6/-	SP61	2/-	3B24	3/-	6N7GT	7/-	35Z4	5/-	8013A	10/-
AU4	5/-	EF52	5/-	MPT42	5/3	SP210	4/-	3E29		6Q7G	6/3	35Z4GT	7/-	8020	6/-
AW3	4/-	EF54	3/6	MS/PEN	6/-	STV280/40	12/-	(829B)	60/-	6R7G	7/6	39/44	6/-	9001	5/-
BL63	6/-	EF55	6/-	N34	8/-	SU2150A	4/9	3Q5GT	9/-	6R7GT	8/-	53A	3/-	9003	5/6
BT45	40/-	EF70	4/-	NR15A	3/-	T41	7/-	3V4	7/3	6SA7	6/-	58	6/-	9004	4/-
BT9B	40/-	EF80	6/9	NT37		TP25	15/-	4A1	4/6	6SC7G	5/6	59	6/-	9006	4/-
D41	3/3	EF85	6/10	(4033A)	10/-	TT11	3/-	4D1	2/6	6SC7GT	6/-	71A	4/6		
D42	4/-	EF86	9/-	OD3	5/-	U17	5/-	5U4G	5/-	6SG7	5/-	77	6/-	Cathode Ray Tubes:	
D77	4/3	EF89	8/9	P2	4/-	U18	6/6	5Y3GT	6/9	6SH7	5/-	78	7/-		
DA30	12/6	EF91	4/10	P61	2/6	U27	8/-	5Z3	8/6	6SJ7	6/9	80	6/3	3BP1	25/-
DAF86	8/-	EF92	5/-	PCC84	8/-	U52	5/-	5Z4G	8/-	6SF5	8/-	82	8/-	5BP1	35/-
DET5	15/-	EF95	7/6	PCC85	8/-	UL84	8/6	6A6	5/-	6SJ7G	6/6	83V	12/-	5CP1	42/6
DET19	2/6	EL32	3/9	PCF80	8/-	UL85	7/-	6AB7	5/-	6SK7	5/6	84	8/-	5FP7	45/-
DET20	2/6	EL35	9/-	PEN25	4/6	U89	5/6	6AC7	4/3	6SL7GT	6/9	84	12/6	VCRX258 (with scanning coil)	45/-
DF70	9/-	EL41	8/3	PEN46	5/6	V2D33B	8/-	6AG5	4/6	6SN7GT	4/6	85A1	12/-		
DF72	7/6	EL42	9/-	PEN65	6/6	V226	5/-	6AG7	8/-	6SQ7	6/6	89	6/-		
DF96	8/-	EL84	8/3	PEN220A	3/-	V248A	8/-	6AJ7	4/3	6SR7	6/6	210LF	3/-	Photo Tubes:	
DH76	4/9	EL85	10/-	PENDD/		VMP4G	6/-	6AK6	7/6	6SS7	5/-	210VPT 7 pin	2/6		
DK96	8/-	EL91	7/6	1360	9/6	VP23	3/6	6AK7	8/-	6V6G	5/6	217C	17/6	GS16	12/6
DL72	7/6	ESU208	8/-	PG7/5	15/-	VR78	4/-	6AM5	5/-	6V6GT	6/-	446A	14/-		
DL71	8/-	EY51	8/3	PL81	11/-	VR99	8/-	6AM6	6/3	6X4	5/6	705A	17/6	Special Valves:	
DL96	8/-	EY91	3/6	PL82	8/-	VR105/30	7/6	6AT6	7/-	6X5GT	6/6	715B	97/6	2J31	45/-
E1232	5/6	EZ40	7/-	PL83	9/-	VR150/30	7/3	6B8	5/6	6Z4	8/-	717A	8/6	3A/1481	45/-
E1323	25/-	EZ80	7/6	PM4DX	3/-	VS110	4/-	6B8G	2/6	723A/B	45/-	801	6/-	3J/170/E	£35
E1524	6/6	FW4/500	6/6	PM24A	4/-	VT25	8/-	6C4	4/-	7Q7	7/-	803	22/6	3J192/E	£37/10
EA50	1/6	H30	5/-	PT25H	7/6	VU111	3/3	6C5	6/-	8D2	2/6	805	30/-	723AB	52/6
						VU120	3/-	6C6G	4/6	9D2	3/-	807 AMER.	7/-	726A	27/6
						VU133A	3/-	6C8G	5/-	10Y	8/6	807BR	5/-	ACT25	40/-
						W21 4 pin	7/-	6E5	5/-	12A6	5/-	808	8/-	CV691	60/-
						W31	7/-	6F5G	5/6	12AH7	7/-	813	67/6	KR3	45/-
						Y63	5/-	6F6	7/-	12AT7	6/6	815	80/-	VX7110	15/-
						Y66	8/-	6F8G	6/6	12AU7	6/9	816	30/-	WL417A	15/-

AND MANY OTHERS IN STOCK including Cathode Ray Tubes and Special Valves.

All U.K. orders below 10/- P. & P. 1/-; over 10/- 1/6; orders over £3 P. & P. free. C.O.D. 2/- extra. Overseas Postage extra at cost.

BRAND NEW ORIGINAL SPARE PARTS FOR AR88 RECEIVERS.
Please write your requirements.

MOVING COIL ROUND HAND MICROPHONE No. 13. 2½in. diam. with press switch. **12/6.** P. & P. 1/-.

COSSOR DOUBLE BEAM OSCILLOSCOPE 339A. Fully tested and working, **£15.** Carriage 10/-.

HRO MAINS power pack, input 115/250 v. A.C. Output 250 v. 75 mA. and 6.3 v. 3.5 amps. **£3,** inc. carr.

VARIOMETERS for W/S No. 19. Fully tested and working **12/6.** P. & P. 2/6.

TRANSMITTER CABINET with door at back. 77in. high x 29in. wide. Rack fitting type. **£17/10/-.** Carr. **£1.**

FERRANTI TRANSFORMER. Oil cooled. 20/19.5 KVA, 3 phase 50 cycles. Pri. 360-380-400-420-440 volts. Sec. 2700-2900-3100-3300-3500 volts. 2.1 amps. Voltage regulation by simple switch. Pri. and sec. Weight 1,150 lb. Price **£125.** Carr. at cost.

FILAMENT TRANSFORMERS. Primary 0–190–210–230–250 v., 50 c/s. Sec. 1. 2.5 v. CT at 10 amps. 2. 2.5 v. CT at 10 amps. 3. 10.5 v. CT at 11 amps., 4,000 v. insulation. Price **£2/19/-.** P. & P. 5/-. Primary 0–190–210–230–250 v. 50 c/s. Sec. 1. 10 v. CT at 4.5 amps. 2. 10 v. CT at 4.5 amps., 4,000 v. insulation, **£1/16/-.** P. & P. 5/-. Primary 230 v. 50/60 c/s. 67 v/amps. Sec. 1. 6.3 v. 1–6 amps. 2. 6.3 v. CT 3 amps. 3. 6.3 v. CT 3 amps. 4. 6.3 v. CT 3 amps., **£1/12/-.** P. & P. 5/-.

LOW RESISTANCE HEADPHONES. Brand new, balanced armature, DLR, **7/6.** P. & P. 1/-.

TELEPHONE HANDSET. Standard G.P.O. type, new, **12/-.** P. & P. 1/6.

B.C. 659 TRANSMITTER/RECEIVER, frequency range 27–38.9 mc/s. crystal controlled two preset channels, together with power unit for 6, 12 or 24 v. D.C. good condition, **£5/10/-.** Carr. 15/-.

NEW PRODUCT OF TAYLOR

Model 127A Pocket size meter. Sensitivity 20,000 o.p.v. D.C. 1,000 o.p.v. A.C.
20 ranges.
D.C. current 50μA to 1 amp.
D.C. volts 0.3 v.–1,000 v. (25 kV. by probe).
A.C. volts 10 v.–1,000 v.
3 resistance ranges from 0–20 megohms (self contained). Metre 40μA 3½in. arc. Accuracy D.C. 3% A.C. 4% ohms 5%.
Dimensions 5¾ x 3¾ x 1¾in. Weight 14 oz. Price **£10** complete with instruction manual, test prods and clips. Leather case **£1/12/-** extra.

OUTPUT TRANSFORMER, in screening can giving 9 different ratios 10 : 1 up to 120 : 1 for battery receivers or any high resistance pentodes used as output valves, **6/6.** P. & P. 1/6.
DRIVER TRANSFORMERS. Primary 500 ohms imp. Sec. to match two 805 in push-pull **£1/7/6.** P. & P. 5/-.
TRANSFORMERS. Relay supply Primary 230 v. Sec. 0–27/29/31 v. at 0.5 amps., **15/-.** P. & P. 5/-.

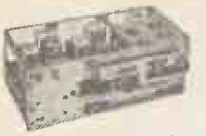
ROTARY TRANSFORMERS. 171 watt, 12 v. input. 1,600 v. 110 mA. output, **30/-.** P. & P. **7/6.**
COMPLETE SET OF STRONG AERIAL RODS (American). Screw-in type MP47, 50 51, 52, 53, total length 15ft. 10in. top diameter 0.615in., bottom diameter 0.185in., together with matched aerial base. MP37 with ceramic insulator, ideal for car or roof insulation. **£2/10/-.** Post free.
SCR 522 RECEIVERS (BC624), 100–156 Mc/s., including all valves, **25/-.** P. & P 5/-.
H.T. CHOKES made by Bendix Radio (U.S.A.) 3 henrys .600A D.C. 25 ohms D.C. resistance 18 volts R.M.S. 60 cycle test **£1/12/6.** P. & P. 6/-.
Ditto 10 henrys 250 Amps. D.C. 90 ohms D.C. resistance 1500 R.M.S. 60 cycle test **16/6.** P. & P. 3/6.
THROAT MICROPHONES T30 U.S.A. **3/6.** P. & P. 1/6.
VIBRATOR UNIT. 12 v./160 v. 35 mAmps. Exceedingly well filtered and smoothed, excellent for car radios. New, including one 6X5G valve and vibrator. **17/6.** P. & P. 5/-.
CARBON INSET MICROPHONE. G.P.O. type 2/6. P. & P. 1/-.
INSULATION TEST METER. Testing voltage adjustable up to 6,000 v. D.C. Mains supply 180/250 v. In wooden case **£25.** Carr. 10/-.
TCS RECEIVERS made by Collins of U.S.A., in fully guaranteed working condition. 1.5–12 Mc/s. line-up: 12S7 (1), 12SQ7 (1), 12A6 (2), 12SK7 (3), power requirements 12 volt L.T., 225 volts H.T. **£11/10/-,** carriage 12/6.
SPECIAL BUILT POWER PACK for the above. 230 volt A.C. mains, including 6X5gt valve. **£3/10/-.** Carriage 5/-.
TRANS-RECEIVER No. 2Z. 2 megocycles to 8 Mc/s Built almost exactly as Number 19. Set much more economical in battery consumption. Complete in fully working condition with power pack for 12 volts, head-gear and microphone, assembly key. **£9/19/6.** Carriage 15/-

P. C. RADIO LTD.
170, GOLDHAWK RD., W.12 SHEpherds Bush 4946

PERSONAL CALLERS WELCOME

V.H.F. RECEIVER UNITS BC-624

(part of SCR-522 Transmitter-Receiver)



4 Crystal controlled channel, 100-156 Mc/s. (3.0-1.93 metres). Valves 9003 R.F. stage; 9003 Mixer; Three I.F. stages 12SG7; Det/AVC/Audio 12C8; Second Audio 12J5GT; Oscillator 2AH7GT, Harmonic Generator 9002; Harmonic Amplifier 9003; Audio Squelch—other section of 12AH-7GT. High and Low Impedance output. PRICE, complete with valves, with description and circuit diagram, but without squelch relay 25/-, p.p. 5/-. PRICE, chassis only, less valves 7/6, p.p. 3/6.

ALSO LIMITED QUANTITY ONLY:

TRANSMITTER UNITS BC-625

(part of SCR-522 Radio Set)

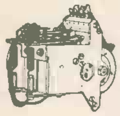
Valves: Speech Amplifier 6SS7; Push-Pull Modulator (two 12A6); Oscillator 6G6G; 1st Harmonic Ampl. 12A6; 2nd Harmonic Ampl. 832; Power Ampl. 832. Output 8 watts.

PRICE, complete with valves, description and circuit diagram .... p.p. 5/-. 22/6

Price, chassis only, less valves ...... p.p. 3/6. 7/6

Descriptions and circuits available at 8d. each.

RATCHET MOTORS, 12 v.



1 Amp. (Impulse Motors) 5.75 ohms .... 3/6 each

Packing and postage .... 1/6.

D.C. SOLENOIDS

Type 700-28 Push-Pull Type, 24-28V, 1 Amp. holding force 12 lbs.; stroke 5/16in. Flange Mounting; Dimensions: 2⅛in. high × 2in. × 2in....... 6/6, p.p. 2/-.

Type 137 Push-Pull Type; 26V. 12 Amps; Holding Force approx. 40 lbs.; Stroke ⅜in.; Dimensions 3⅛in. high × 2⅛in. × 2⅛in.......................... 8/6, p.p. 2/-.

Type 768-2, Pull Type, 28V. 17.5 Amps; Holding Force approx. 50lbs.; Stroke ⅜in. Dimensions 3in. high × 2⅛in. × 2⅛in. Flange Mounted.... 8/6, p.p. 2/-.

PORTABLE METERS

EX-A.M., 150 Volts D.C. M.C., in bakelite cases, with side terminals. Dimensions: 6⅛in. × 6⅛in. × 3⅛in. deep.

PRICE .... 35/-, p.p. 3/9.

VENNER 8-day clockwork time switches. 24-hour dial with one make and one break. 1 amp. 230V. contacts. Second-hand, good condition, complete with winding key .... p.p. 2/-. 27/6

HIGH SPEED RELAYS

SIGMA 4C1 or ALLIED TYPE "G." 1B, 5,000Ω, Current 4 mA ±.5 mA; 2in. dia. × 2in. high. Second-hand .... 5/6, p.p. 1/6

ROLLER-SMITH MOVING COIL CURRENT RELAY

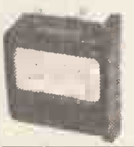
nominal setting 1.5A D.C. with adjustments of ±20%. Coil Resistance approx. .9Ω. One changeover contacts 200 mA. capacity. Switchboard mounting 35/-, p.p. 4/-

P.O. BUZZERS

Post Office Buzzers model T Mk. I. Minimum operating voltage 3 volts. PRICE (p.p. 1/6).............. 4/6

WESTINGHOUSE RECTIFIER POWER SUPPLY UNIT Input 115/230V; fully smoothed and fused. Output adjustable from 80 to 140V. D.C. at 400mA continuously. Dimensions: 17⅛in. wide × 10⅛in. deep × 3⅛in. high .... p.p. 7/6. £2

3-RANGE MICRO-MILLIAMMETER



Basic movements 50μA D.C. M.C. Ranges of 30μA, 250μA and 1mA switched by a trigger switch in the back, geared with sliding scale having separate graduations for each range. Instrument is fitted with leads for soldering to test prods or crocodile clips (not supplied) 50/-

WESTINGHOUSE SELENIUM RECTIFIER POWER UNITS

Input 115/230V., fully smoothed and fused. Output adjustable from 80 to 140V. D.C. by means of fine and coarse tap switches in the secondary winding. Maximum current 400mA. continuous. Dimensions: 17⅛in. × 10⅛in. deep × 3⅛in. high.......... p.p. 7/6. 49/-

AVO CR BRIDGES

Portable Mains Operated Serviceman's Component Bridge. Ranges of measurements; Capacity from 5mmF. to 50 mF.; Resistance from 5 ohms to 50 megohms. Valve Voltmeter from 0 to 15 V. RMS: Neon Leakage Indicator. Power Factor measurement in %.

PRICE .... p.p. 10/- £9

NEW FOREIGN MADE POCKET MULTIMETERS

Basic Movement 300μA. Sensitivity 1,000Ω/V. A.C. and D.C. Ranges: 10-50-250-500-1,000V. D.C. and A.C. 1-100-500mA. D.C., 2K/200K ohms. Accuracy: 3% FSD and D.C., 5% FSD on A.C. 10% on. Resistance scale. Dimensions: 5⅛in. × 3⅛in. × 2⅛in. Complete with test leads with prods and 1.5V cell, fully guaranteed 80/-.

METERS

25-0-25μA D.C. MC 2⅛in. Rd. Proj.	45/-
50μA D.C. MC 2⅛in. Rd. Fl. Panel Mtd.	45/-
50μA D.C. MC 4⅛in. Sq. Fl. Mtd. SIFAM	65/-
200μA D.C. MC 2in. Rd. Fl. Mtd.	32/6
200μA D.C. MC 2⅛in. Rd. Fl. Mtd.	35/-
200μA D.C. MC 2⅛in. Sq. Fl. Mtd.	35/-
500μA D.C. MC 2⅛in. Rd. Fl. Panel Mtd.	17/6
500-0-500μA D.C. MC 3⅛in. Rd. Fl. Mtd., calibrated 50-0-50 yards per second:	
Western Electric	22/-
Weston	25/-
1mA D.C. MC 2in. Rd. Fl. Mtd., mounted in a 2⅛in. square steel box with test lead	20/-
5 mA. D.C. MC 2in. Rd. Fl. Mtd.	17/6
50mA D.C. MC 2⅛in. Rd. Fl. Mtd.	15/-
200 mA D.C. MC 2in. Rd. Fl. Mtd., Black scale	12/6
500-0-500mA D.C. MC 2⅛in. Rd. Fl.	12/6
2 Amps. D.C. MC 2in. Rd. Fl. Mtd.	15/-
5 Amps D.C. MC 2⅛in. Rd. Fl. Mtd.	17/6
5-0-5 Amps. D.C. MC 2⅛in. Rd. Fl. Mtd.	16/6
10V D.C. MC 2in. Rd. Fl. Mtd.	15/-
10V D.C. MC 2⅛in. Rd. Fl. Mtd.	17/6
30-0-30V D.C. MC 2⅛in. Rd. Fl. Mtd.	15/-
150V A.C. MI 2⅛in. Rd. Fl. Mtd. Black Scale	20/-
300V A.C. MI 2⅛in. Rd. Fl. Mtd.	20/-
300V A.C. MI 6in. Rd. Fl. Mtd., Turner, calibrated to BSI Grade I	85/-

Please send S.A.E. for full list of meters. Please add 2/6 in £ for postage and packing.

REVERSIBLE 12 V. D.C. MINIATURE MOTORS

Power approx. 5 watts at 7,000 R.P.M. Dimensions 1⅛in. long × 1⅛in. dia. Shaft .077in. dia. × 4in. long. Centre of reversing switch integral with the motor. Self-lubricating sintered bronze bearings. PRICE, brand new, 15/6 post free.

21-point JONES PLUGS and SOCKETS

(Standard Size), per pair. 7/6, p.p. 9d.

TESTED AND GUARANTEED VALVES

OA2	6/-	5R4GY	9/-	6L5G	6/-
OD3/VR150	5/6	5T4	9/-	6L6	9/-
1A3	3/-	5U4G	9/-	6L6G	7/-
1AH4	5/-	5V4G	9/-	6L7	5/-
1L4	3/6	5Y3GT	6/-	6L7G	4/6
1Q22	100/-	5Z3	7/-	6N7	6/-
1R4	7/-	5Z4M	9/-	6N7G	5/-
1R5	6/-	6A6	5/-	6Q7G	6/-
1S5	6/-	6A7	8/-	6R7	6/-
1T4	5/-	6AB4	5/-	6SA7	6/-
1U5	6/-	6AB7	4/-	6SA7GTY	5/6
1V2	4/-	6AC7	3/-	6SC7	7/-
2C26	3/-	6AG5	3/6	6SG7	6/-
2C26A	3/6	6AG7	6/-	6SH7	4/-
2C34	4/6	6AK5	5/-	6SJ7	5/-
2C39A	100/-	6AL5	4/-	6SK7	5/6
2C40	40/-	6AM5	5/-	6SN7GT	4/-
2C42	25/-	6AM6	4/6	6SQ7	6/-
2C43	40/-	6AQ5	7/-	6SS7	3/6
2C46	30/-	6AQ6	7/-	6X4	5/-
2C50	30/-	6AR6	5/6	6X5GT/G	5/-
2D21	9/-	6AT6	5/-	6V6	5/6
2X2	4/-	6AU6	7/-	6Z4	6/-
3A4	5/-	6AV6	6/-	7A4	4/-
3A5	5/-	6B4G	4/-	7AG7	5/-
3B22	20/-	6B7	6/-	7C7	5/-
3B24	3/6	6B8	6/-	7E5	5/-
3B26	20/-	6B8G	3/6	7F7	6/-
3B29	30/-	6BF6	5/-	7N7	5/-
3C45	30/-	6BN6	7/-	7W7	6/-
3D6	4/-	6C4	2/6	11E2	20/-
3D21	30/-	6CB6	4/-	11E3	20/-
3Q4	7/-	6C5G	7/-	12A6	3/-
3S4	5/-	6C8G	7/-	12AH7GT	4/6
3TF7	7/6	6D4	10/-	12AT7	6/-
4B32	40/-	6F6	5/-	12AU7	6/-
4B28	15/-	6F8G	6/6	12AX7	7/-
4E27	60/-	6G6G	2/6	12C8	3/-
5B21	20/-	6H6	1/6	12H6	2/-
5B/502A	80/-	6J5	4/6	12J5GT	1/6
		6J5G	3/-	12SH7	3/-
		6J6	3/6		
		6K7	5/-		
		6K7G	4/-		
		6K8	9/-		

12SK7	4/-	703A	30/-	808	12/6	931A	60/-	4043	15/-	5702	15/-
12SQ7	8/6	705A	15/-	811A	30/-	955	4/-	4061A	10/-	5718	6/-
12SX7GT	8/-	717A	4/-	813	70/-	956	2/-	4242A	35/-	5725	7/-
14A7	6/-	801A/801	10/-	815	40/-	957	5/-	4274A	15/-	5763	12/6
24G	30/-	807(US)	6/6	829B	60/-	1616	7/-	5517	6/-	5786	200/-
25Z6GT	6/-	807(UK)	5/6	832	15/-	2050	7/6	5678	7/-	5787	10/6
41	5/-			832A	35/-	4033A	15/-	5687	10/-	5814	9/-
				927	15/-	4033L	30/-	5693	20/-	5829	6/-

CATHODE RAY TUBES

Type	dia.	V_h	V_{a1}	V_{a2}	V_g	Screen	Defl.	Focus	Price
3ACP2	3in.	6.3	545V	2,000V	60V	Gr.	ES	ES	20/-
2AP1	2in.	6.3	250V	1,000V	60V	Gr.	ES	ES	25/-
5FP7	5in.	6.3	250V	7,000V	45	Gr/Y	EM	EM	12/6
5SP7*	5in.	6.3	430V	1,500V	30	Gr/Y	ES	ES	140/-
7BP7	7in.	6.3	330	7,700V	45	Gr/Y	ES	EM	45/-
7BP7A	7in.	6.3	770	8,800V	70	Gr/Y	EM	EM	60/-
10UP21	10in.	6.3	770	13,000V	70	Y/R	EM	EM	70/-
12SP7	12in.	6.3		9,000V	250	G/Y	EM	EM	40/-
CV961	7in.	4.0	450	500	70	Gr.	ES	ES	25/-
CV956**	12in.	4.0	1,700	1,200	90	Gr.	ES	ES	15/-

STEEL SCREENS FOR 3in. TUBES.................................. 5/- P.P. 9d.

*Twin Gun.

**Complete with mu-metal screen.

Packing and carriage 2/- in £ subject to a minimum of 2/6.

53A	3/-
54G(HK)	25/-
76	5/-
83V	9/-
154	40/-
249B	25/-
267A	15/-
284B,D	20/-
313C	30/-
323B	40/-
350A	15/-
357A	100/-
393A	20/-
559	3/-

KLYSTRONS

Type	V_h	V_{res}	P_{res}	Output	Freq.	Price
417A	6.3	1,000	50W	25mW	9.1-11.3cm	40/-
723A/B	6.3	330		20mW	8,702-9,548mc	50/-
CV129	4.0	1,600	10W	75mW	9,375mc mean	80/-
CV238	4.0	250	8W	100mW	3,030mc mean	40/-
CV35	4.0	1,250	10W	100mW	3,033mc mean	100/-
CV217	4.0	1,350	10W	15mW	9,738mc mean	40/-

MAGNETRONS

5330, Vh 2.2Va 2,500 peak, 1,500 gauss, output 150 Watst, frequency 375mc mean, liquid cooled, 40/-.

725A, Vh-6.3V; Va-16kV pk; 5,400 gauss; frequency 9,375 mc/s mean, 60/-.

5839	25/-
5852	10/-
5899A	10/-
5932	15/-
5963	7/-
5998	15/-
6064	10/-
6065	10/-
6073	7/6
6100	10/-
6213	15/-
7193	2/-
8016	5/-
9001	4/6
9002	5/6

9003	6/-	EL38	15/-	UL84	8/-
9004	4/-	EL84	7/-	VGT128	10/-
9006	2/6	EZ80	6/-	VR21	2/6
AC/HL	5/-	EY51	9/-	VR35	5/-
ACT-19	80/-	EY86	10/-	VR53	4/-
ARDD5	1/6	FW4/800	8/6	VR54	1/6
ARP34	4/-	KT33C	6/-	VR56	4/6
ARTH2	7/-	KT63	6/-	VR65	4/-
ATP4	5/-	KT66	12/6	VR92	1/-
AW3	4/6	KT81	17/6	VR-100	7/-
ATR387	70/-	KTZ63	9/-	VR135	2/6
C3R14	10/-	L63	6/-	VR136	4/-
CK522AX	10/-	MH4	6/-	VR137	4/-
DAF96	7/6	MHL4	3/6	VS68	4/6
DF96	7/6	ML6	6/-	VT31	50/-
DH63	6/-	PEN44	20/-	VT52	4/6
DK96	8/-	PCC84	9/-	VT61	7/-
DL94	6/6	PCF80	9/6	VT501	3/-
DL95	7/-	PL36	13/-	VU39	7/-
DL96	7/6	PL81	10/-	VU111	4/-
SL10	4/-	PL82	8/6	VX3208	5/6
EABC80	8/-	PL83	11/-	VX8190	5/6
EAC91	4/-	PT15	15/-	VX8142	5/6
ECC81	6/-	PY81	8/6	Z21	10/-
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Printed in Great Britain for the Publishers, ILIFFE & SONS LTD., Dorset House, Stamford St., London, S.E.1, by CORNWALL PRESS LTD., Paris Garden, London, S.E.1. *Wireless World* can be obtained abroad from the following: AUSTRALIA and NEW ZEALAND: Gordon & Gotch, Ltd. INDIA: A. H. Wheeler & Co. CANADA: The Wm. Dawson Subscription Service, Ltd.; Gordon & Gotch, Ltd. SOUTH AFRICA: Central News Agency, Ltd., William Dawson & Sons (S.A.), Ltd. UNITED STATES: Eastern News Co., 306 West 11th Street, New York 14.

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