Wireless World

RADIO, TELEVISION AND ELECTRONICS

43rd YEAR OF PUBLICATION

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In This Issue

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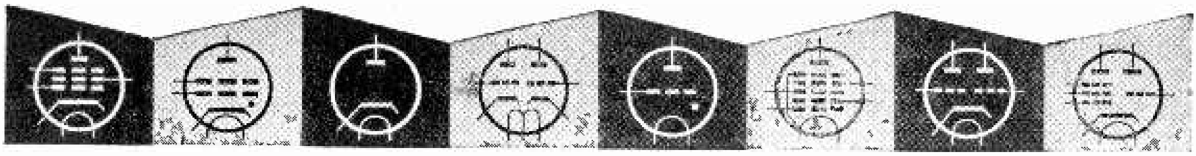
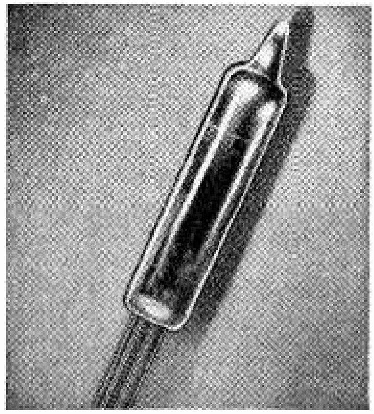


VALVES, TUBES & CIRCUITS

6. DM70—SUBMINIATURE TUNING INDICATOR FOR BATTERY OR MAINS RECEIVERS (Contd.)

APPLICATION IN VARIOUS TYPES OF RECEIVERS



Battery Receivers Those receivers provided with a 90-volt battery operate with an h.t. of about 85V after deducting the negative grid bias required for the output valve. In such a receiver a DM70 connected with pin 4 earthed has a cut-off voltage of −10V, which is adequate to indicate the strongest signal likely to be encountered. Similarly for a 67.5V battery, the h.t. is of the order of 60V giving a cut-off voltage of −7V when connected with pin 5 earthed.

A.B.C. Receivers In an A.B.C. receiver it is usually necessary to connect the filament of the DM70 in series with the filaments of the other valves. With a chain of valves having 50mA filament the 25mA filament of the DM70 should be shunted by a 56Ω resistor. The positioning of the DM70 in the filament chain needs careful consideration to ensure that the values of grid voltage at zero and at maximum signal give the optimum amount of indication on the DM70.

A.C. Mains Receivers The filament of the DM70 can usually be fed from a 6.3-volt transformer winding through a series resistor of 220Ω 5±%. Alternatively, a 3.15V centre-tap on the heater supply can be used, the value of the series resistor then being 82Ω ±10%.

It is not recommended that the filament of the DM70 be fed with a direct current from the cathode resistor of the output valve owing to the possibility of wide variations in this current resulting in reduced life of the indicator.

The recommended anode voltage for the DM70 in mains receivers is 60V, which can be obtained from the h.t. line by means of a series resistor. This results in a sliding anode voltage dependent upon the current of the valve and so extends the range of grid control to deal adequately with strong signals in a very sensitive receiver.

As the filament is supplied with an alternating voltage it is necessary to take precautions to prevent hum being introduced into the a.g.c. circuit from the grid of the DM70.

A.C./D.C. Receivers The filament of the DM70 shunted by a suitable resistor may be connected in series with the heaters of the other valves in an A.C./D.C. receiver provided a surge current limiting device is also included in the series circuit. For mains voltages above 160V the shunt resistor should be 18Ω ±10% when included in a 100mA heater chain.

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Exhibitions

IT would be ungracious—and indeed, foolish— to complain that too much limelight is thrown on our art. All the same, the very large number of exhibitions concerned with radio and electronics are something of an embarrassment to many people, including visitors and exhibitors as well. Although almost all the exhibitions with which we are concerned nowadays are in fact, if not in name, specialized, there is a good deal of overlapping between them. Manufacturers, naturally enough, want to show their products to the largest number of potential users, who, in their turn, want to see what is available to them. But is it possible to avoid the present duplication of effort and to reduce the expenditure of man-hours and money by both exhibitors and visitors?

An exhibition organized by the Radio Communication and Electronic Association, with collaboration of the Ministry of Supply, was held recently at Farnborough for the benefit of delegates from the European Defence Community, N.A.T.O. and the British Commonwealth. It was supported by firms in the components and valve sections of the radio industry, and though outwardly of a military character, did in fact cover a much wider field. With some justification this was claimed to be "the most comprehensive display of electronic equipment held anywhere in the world." The pity of it is that this impressive show, which presented the "professional" side of the industry as it has never been presented before, was seen by a mere handful of visitors.

The success of the Farnborough show gives rise to the thought that, for purposes of exhibitions, all radio could be divided into two sections, which might very roughly be described as professional and domestic. The first category would include all products for communication, industrial, commercial and military applications. The domestic show would, of course, deal predominantly with broadcast receiving equipment, but might also cover electronic equipment intended to some extent at least for the general public, including perhaps "business radio." The advantage would be that annual exhibitions organized in this way would provide a focal point of the year for developments in the main spheres of activity. Such a scheme might not entirely avoid the need for specialized exhibitions, but would at least allow them to be still more specialized, and thus obviate much of the wasteful overlapping that now occurs.

Television Conversion

A LETTER from a correspondent, printed elsewhere in this issue, expresses the view that the problems involved in designing converters for adapting existing television receivers for reception of the proposed alternative service are rather more difficult than is commonly believed. No doubt, certain types of set, operated in favourable conditions, could be fairly simply adapted, but it does seem most unlikely that a standardized design of converter, applicable to all sets in all conditions, could be produced at low cost.

The tunable receiver having channel selection under the control of the user will lend itself more readily to conversion to the new band, and so it is to be expected that this type of set will become increasingly popular when the start of the alternative service becomes imminent.

An allied problem that has not yet been touched upon at any length is that of aerials for two-band reception. That is one of the many matters connected with the proposed alternative television service that we hope to discuss in detail in the near future.

Local Conditions

THE task of the B.B.C. in providing an acceptable medium-wave signal for the whole country is not an enviable one, and becomes more difficult as time goes on. To an increasing extent, compromises are necessary. Critics of B.B.C. quality are inclined to overlook the fact that a transmitting technique that satisfies the listener who lives, figuratively speaking, on the doorstep of a station is quite unacceptable to those in the wilds. The only way out of this difficulty lies in the use of v.h.f.

Components and Techniques

Survey of the R.E.C.M.F. and Physical Society's Exhibitions

Since the above two exhibitions ran more or less concurrently in London this year and also overlapped to some extent in their types of exhibits, we have selected the most interesting items from both shows and combined them into this one report. No distinction is made between Physical Society exhibits and R.E.C.M.F. exhibits, but each section dealing with components is followed by a list of the exhibitors in that class.

RESEARCH AND MATERIALS

The problems of noise measurement in fractional-ohm resistors at temperatures of the order of 20 deg K (−253 deg C) are formidable and offer an interesting challenge to the amplifier designer. These have been successfully solved in an amplifier designed by P. J. Baxandall at the Telecommunications Research Establishment. Two input transformers are used, the first operating at low temperature and stepping up to 300 in order that the leads to the refrigerant container shall be thin enough to avoid too much loss by heat conduction; the second transformer provides an impedance of 1 MΩ at 4,000 c/s. In designing the first transformer it was found that at 20 deg K the permeability of Mumetal falls to a third of its normal value, but the shunt eddy-current losses are not appreciably effective. At the level of the noise to be measured microphony in the input transformers is a serious factor, and anti-vibration mounting is necessary. In order to reduce shot noise in the first stage, an ME1400 version of the EF37A was used under electrometer conditions with an anode current of 110 μA and grid current of $10^{-4}\mu$A. When used with a tuned circuit having a Q of 50 to 800 c/s, the noise factor was 2.7 db (a figure of 3 db was stipulated).

A compact selective amplifier for the analysis of fluctuation noise in germanium rectifiers has been developed by the Radio Research Station, Slough. The basis is the RC circuit due to Schneider (*Phil. Mag.* 1945, Vol. 36, p. 371) and five resonant frequencies are provided at 0.1, 0.04, 0.02, 0.01 and 0.005 c/s with an effective Q of 8.

The transparency to infra-red radiation of germanium is exploited in a demonstration, by T.R.E. of the modulation of a beam. The transmission of infra-red through the germanium is dependent on the number of current carriers present in the germanium and this can be varied by applying an audio signal to a contact fulfilling a similar function to the emitter in a transistor. It was shown that some plastics with high light transmission are relatively opaque at the frequency used, 1.5×10^8 Mc/s (2 microns).

Selenium in its amorphous form is also transparent to radiation from the infra-red to centimetre wavelengths, and "optical" components such as prisms and lenses have been made by a simple casting technique by the Services Electronics Research Laboratory, Baldock.

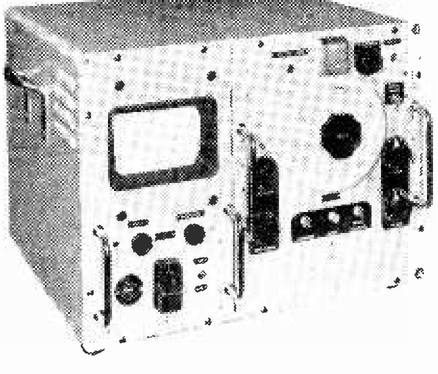
An infra-red image converter tube has been applied by Prof. B. K. Johnson (Imperial College) to the microscopy of opaque specimens, and is being used in the examination of minerals for the identification of uniaxial and biaxial crystals.

The detection of impurities in air by the change in emission and surface potential of a prepared plate at normal temperatures was demonstrated by the Signals Research and Development Establishment (Christchurch) using a vibrating capacitor in association with a selective phase-sensitive amplifier-detector. Potential changes of the order of 10 μV can be measured.

Exploration of the wavelengths and field patterns associated with different oscillation modes in a magnetron is effected in apparatus designed by S.E.R.L., Baldock, by means of a rotating pick-up probe extending from the surface of the cathode. The anode is excited by a tunable oscillator and mode "contamination" is readily visible on a c.r.t. display. By changing the axial positions of the excitation and pick-up probes, longitudinal distributions of r.f. voltage can be explored.

Some results of research into the effects of irradiation of insulants by radioactive emanations has been disclosed by the Ministry of Supply. Cross linking in long-chain polymers, such as polyethylene, affects not only the mechanical and chemical properties such as elasticity, melting (transition) point and solubility, but also the power factor which is increased at 65 c/s and 1 Mc/s, but appears to be unchanged at 9,000 Mc/s.

Although well past the "breadboard" stage a G.E.C. wide-band panoramic v.h.f. receiver developed by the Research Laboratories is conveniently included in this section, if only to show that there can be no hard dividing lines between research, development and production. It is of the double superheterodyne type and gives c.r.t. display of all signals in bands 10 Mc/s wide between 80 and 220 Mc/s. Sensitivity for twice peak noise level is 10 μV, and limitations usually set to bandwidth by considerations of image rejection have been overcome by sweeping the second oscillator through the converted signal frequency



G.E.C. wide-band panoramic v.h.f. receiver.

in the i.f. amplifier. Pulses on either side of zero beat for each signal are combined to give a single response in the display. Frequency markers are derived from a quartz crystal.

Materials

Some interesting developments are taking place in the field of magnetic materials which will upset many preconceived ideas on the subject. Having become more or less accustomed to the idea of ceramic (ferrite) permanent magnets such as Mullard "Magnadur," we must now accept *soft iron* permanent magnets. The prediction of Prof. Néel of the University of Grenoble, that pure iron should develop very high cœrcive force when the particle size is of the order of magnitude of a magnetic domain, has been experimentally confirmed and is found to be a maximum when the crystal size is between 0.1 and 0.01 micron. Above and below these limits the material exhibits its familiar "soft" characteristics. The problems of producing the right grade of power have been solved and G.E.C. in this country are now supplying "Gecalloy Micropowder" magnets in a variety of shapes. The powder has strong cohesive properties and can be cold pressed at normal temperatures without a binder, though a binder is an advantage in some applications. Like the ferrites, micropowder magnets are light, easily moulded and have low eddy current losses, but they have the added advantage of mechanical softness and ease of working. Their properties can also be controlled and in particular the ratio of remanence to coercivity can be varied over a wide range. Energy content ranges from 0.5 to 1.7×10^{6} gauss-oersteds according to the grade of the material and coercive forces up to 700 oersteds are available.

Among conventional magnetic alloys the introduction by Telegraphic Construction and Maintenance of a new series of high-saturation alloys with properties comparable with Permendur, but with better machining qualities was noted; and Swift Levick are now producing columnar crystal anisotropic permanent magnets in simple shapes on a quantity basis. Made under the trade name of "Columax" this alloy has an average energy content of 6.8×10^{6} gauss-oersteds compared with 5×10^{6} for Alcomax III.

London Electric Wire (Lewcos) are now producing instrument wires with p.t.f.e. coatings from 0.0005 to 0.0015in thickness with adequate adherence and abrasion resistance to withstand normal hazards of winding. Synthetic enamel coatings with greater abrasion resistance than conventional oil-based enamels are now available, under the name "Diamel," on precision resistance wires made by Johnson, Matthey. A new range of wires introduced by B.I. Callenders and known as "Fifty Three" have a new strongly adherent and abrasion resistant enamel coating with mechanical and electrical properties intermediate between oil-base and vinyl acetal enamels. Non-stretching binding twines, treated with p.v.c., and designed to withstand tropical acceptance tests, are now available from Associated Techincal Manufacturers.

Although, for all practical purposes, modern activated rosin solder fluxes are non-corrosive, there is still prejudice against their use in some quarters, and ordinary rosin is used in spite of its slow and uncertain fluxing properties. Enthoven have discovered a method of increasing the activity of rosin-cored solder without the use of chemical additives and have marketed the product under the name of "Actol," with a characteristic stellate core, in all standard tin/lead alloys and gauges.

To increase still further the ratio of solder to flux in their three-cored solders "Multicore" have developed an improved activating agent "Pentacol" which will in future be incorporated in their Ersin fluxes which now form 2.2 instead of 3.4 per cent of the total weight. Fluxed solder in tape form is a new departure from Multicore. It can be wrapped round a pair of wires and makes an effective joint when heated by a match flame.

Aluminium soldering has always been regarded as difficult, but a new process developed by the Sheffield Smelting Co., shows more than usual promise and can be carried out with ordinary torch flames at a temperature of 450 deg C. The joints will withstand the accepted accelerated corrosion tests.

Makers*: Associated Technical Manufacturers (B, C, IM, IS, W); Bakelite (IM); Geo. Bray (CE); B.I. Callenders (C, CO, IS, W); British Moulded Plastics (IM); Bullers (CE); Clarke (CF, IM, IS); Connollys (IM, W); De La Rue (IM); Duratube and Wire (C, CO, IS, W); Enthoven (S); Fine Wires (W); Hellerman (IM, IS); Henley's (CO, IM, W); London Electric Wire (CO, W); Long & Hambley (IM, IS, RP); Magnetic and Electrical Alloys (L, M); Marrison and Catherall (M); Micanite and Insulators (CF, B, CO, IM, IS); Mullard (DC, M); Multicore (S); Murex (M); Mycalex (IM); James Neill (M); Reliance Wire (B, C, CO, IS, W); Rola-Celestion (D, L, M); Salford (DC, M); Geo. L. Scott (L); S.T.C. (M); Steatite (CE); Suflex (B, CO, IM, IS, W); Swift Levick (M); H. D. Symons (IM, IS); Taylor Tunnicliff (CE); Telcon (C, DC, L, M, W); Thermo Plastics (CF, IM); Transradio (C. IS, W); United Insulator (CF, CE, IM); Vactite Wire (W).

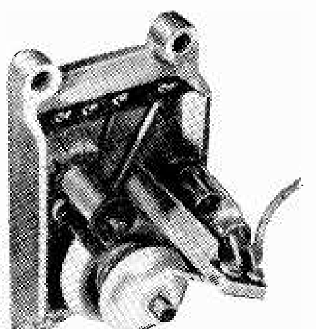
* *Abbreviations*: B, braiding; C, cables; CE, ceramics; CF, coil formers, bobbins; CO, cords; DC, dust cores; IM, insulating materials; IS, insulating sleeving; L, laminations; M, magnets and magnetic alloys; RP, rubber products; S, solder; W, bare or covered wires.

COMPONENTS AND ACCESSORIES

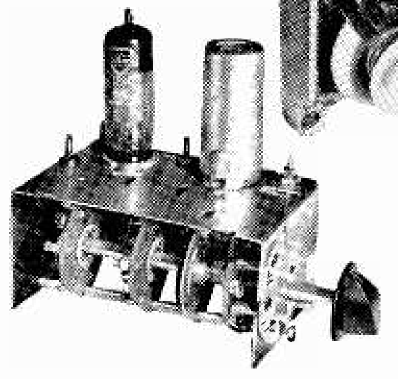
The fact that we now have five television channels all occupied is emphasized this year by the appearance of a five-channel tuner for receivers. Made by Cyldon it has an EF80 r.f. amplifier and an ECC81 frequency changer, and the channels are selected, not by a continuously variable control, but by switching in incremental inductances. The power gain of the unit is 24db and the i.f. output can be either in the band 9.5-14 Mc/s or the band 15.5-22 Mc/s according to the receiver manufacturer's requirements.

Another thing which is more of a sub-assembly than a component is the Igranic e.h.t. generator, for use with the new transformerless line scanning circuits. It contains an inductor for boosting the line flyback voltage, an EY51 e.h.t. rectifier and variable inductor for linearity control, the whole being mounted on a moulded base-plate. The unit supplies an e.h.t. voltage of 13.5kV.

For c.r.t. focusing, permanent magnets moulded from insulated metal powder are coming very much to the fore. Having the advantage of high resistivity, they can be placed close to deflector coils without affecting their performance. An example of their use is to be seen in the focus unit made by Elac, designed for wide-angle c.r.



Right: Igranic e.h.t. unit for direct-drive line-scan circuits.



Left: Five-channel television tuner by Cyldon.

tubes. This has two ring magnets mounted with their fields opposing, and focus is controlled by varying the spacing between them—the minimum field being when they are closest together. The unit contains two other rings, magnetized transversely, which can be adjusted to centre the picture.

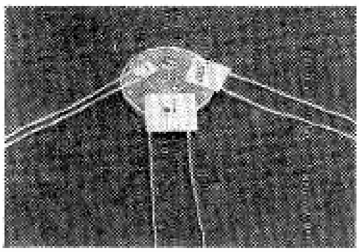
The problem of mounting the variable inductors used for width and linearity control has been solved in one way by Egen Electric, who have combined them into a twin unit, and in another by Plessey, who have stowed them in the mounting bracket of their new, line scan transformers.

Makers: Advance, British Moulded Plastics, Cyldon, Egen, Electro Acoustic Industries, Igranic, Long & Hambly, Magnetic & Electrical Alloys, Mullard, Plessey, Thermo-Plastics, Weymouth, Whiteley.

Capacitors

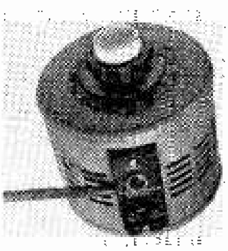
Metallized polystyrene film capacitors figure among the latest T.C.C. products. These are comparable in size to small paper types but have infinitely better characteristics. Capacitances up to 0.5 μF are available. Another plastic film capacitor, also made by this firm, has the exceptionally close tolerance of $\pm\frac{1}{8}$ per cent only and power factor of 0.0005.

The potentially high stability of silvered mica capacitors is not always possible to retain when stacked plates are used, but Johnson, Matthey have introduced a new manufacturing process in which the stack is bonded by firing at a controlled temperature. Reduction in size is claimed as a by-product of this process.

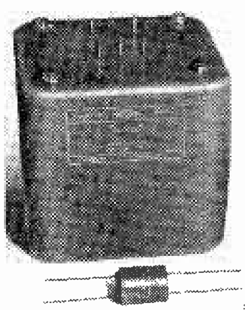


Left: Plessey "Cas-film" silvered ceramic capacitors.

Below: Two of the Parmeko Jupiter range of resin potted transformers.



Above: Zenith twin-brush Variac variable voltage transformer.



Wider temperature ranges are a feature of some of the latest Hunt's capacitors; for example, their "Thermetic Midget" can be used without derating from −100 deg C to +120 deg C.

A new technique is exemplified by the Plessey "Cas-film" silvered ceramic film capacitors. The smallest, measuring 0.2 in square only, provides a capacitance of 0.001 μF at 120 V d.c. working.

Some interesting miniature trimmers for television and v.h.f. applications have appeared this year. Cyldon has a chassis-mounting model with ceramic insulation of 0.5 to 3 pF or 3 to 9 pF, Wingrove & Rogers one of 0.5 to 3.5 pF with P.T.F.E. insulation and Mullard have a new version of their concentric air-dielectric trimmer with precision adjustment.

Makers*: Cyldon (T, V), Daly (E), Dubilier (C, E, M, P, T), Erie (C, T), Hunt (E, M, P), Jackson (T, V), Johnson, Matthey (M), London Electrical Mfg. (C, M), Mullard (T, V), Plessey (C, E, T, V), Stability (C, M), Static (P), Suflex (F), T.C.C. (C, E, F, M, P, T), T.M.C. (F, M, P), Walter (T), Wego (M, P), Welwyn (T), Wingrove & Rogers (T, V).

**Abbreviations:* C = ceramic, E = electrolytic, F = plastic film, M = mica, P = paper, T = trimmers, V = variable.

Resistors

To produce a standard resistance of 0.0001 ohm is in itself no mean achievement, but to guarantee its accuracy to 0.03 per cent demands such skill that few can emulate. Yet standards of this value, increasing in decade steps to 1,000 ohms, are now included in the Sullivan range of standard components. Salford have a new range of precision wirewound potentiometers intended primarily for use in desyn systems. They have tapped windings, single and double elements, twin wipers and provision for 360-deg rotation.

Miniaturization is extending into unusual fields; for example, Painton has introduced a range of miniature faders and attenuators of the type generally used in control consoles. Some are of the edgewise pattern and occupy very little space.

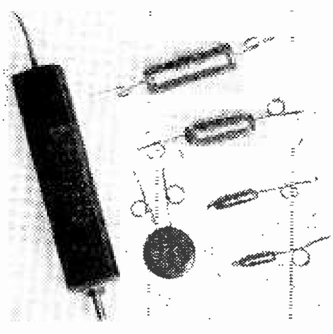
A glimpse into future development was vouchsafed by some unusual fixed resistors shown by the Ministry of Supply. In one case a form of conducting glass is applied to glass plates and rods and then fired to fuse the whole together. In another, microscopic films of one of the precious metals is applied to glass plates and glass fibres. The former is etched to produce long paths and various values of resistance, while the fibres are wound on rods to provide a high resistance in a compact form. High stability is the aim in these designs.

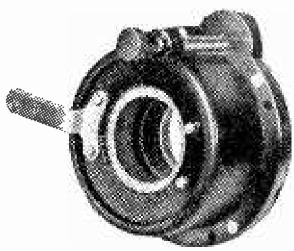
Makers*: Doran (S), Dubilier (C, Hs, W), Egen (C), Erg (Hs, W), Electrothermal (Hs), Electronic Components (C, W), Erie (C, Hs, W), Morganite (C), N.S.F. (C, W), Painton (Hs, W), Plessey (C, W), Pye (W), Salford (W), Sullivan (S), Welwyn (C, Hs, W), Whiteley (C).

**Abbreviations:* C = carbon, Hs = high stability, S = standards, W = wirewound.

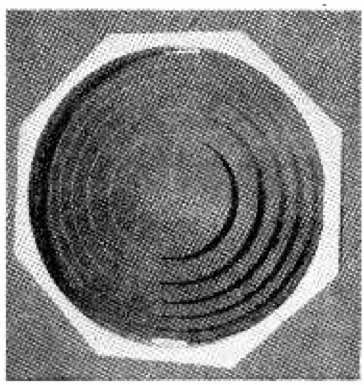
Transformers

The extension of the resin "potting" technique, as used for certain sub-miniature radio assemblies, to the





Left: Selection of T.C.C. latest type capacitors. Above: Elac focusing unit with device for picture centring. Right: Marconi 4-ft metal aerial lens for the 9-mm wavelength.



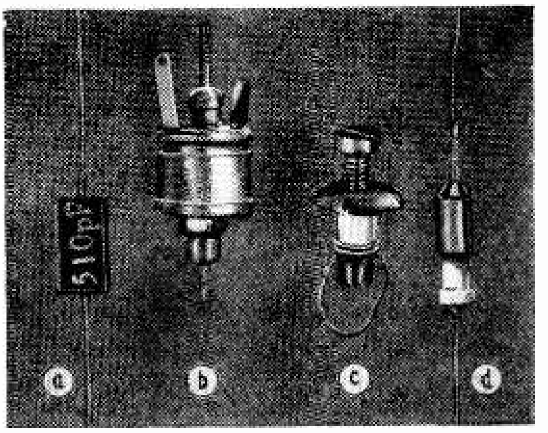
construction of mains transformers may prove an important advance in the design of this class of component. It results in a considerable saving in size and weight of the article and also in the materials used for clamping the core and generally providing either an attractive or functional finish according to the use to which the component is put.

The potting resin not only provides a seamless protective case, but before setting it penetrates all parts of the core and windings and gives internal as well as external sealing. Transformers and chokes constructed in this way are extremely robust and will withstand a considerable amount of rough handling.

Examples of the potting technique as applied to these components are the Jupiter range made by Parmeko and the Pentland series introduced recently by Ferranti.

To the Variac range of variable voltage transformers made by Zenith Electric has been added some new models in open and enclosed types fitted with twin brushes and providing two independently controlled output voltages.

Makers: Advance, Bulgin, Electro Acoustic, Ferranti, Goodmans, Gresham, Igranic, Parmeko, Partridge, Plessey, Rola-Celestion, T.M.C., Weymouth, Whiteley, Woden, Wearite, Zenith.



Some modern miniature trimmers; (b) Mullard air-dielectric with precision adjustment, (c) Cyldon television model, (d) Wingrove & Rogers with P.T.F.E., insulation compared in size with a Hunt's "Micromold" (a) measuring ½-in long.

Aerials

A few minor improvements and one or two new indoor television aerials seem to comprise this year's contribution to broadcast aerial design.

Belling and Lee have modified the reflector (and director) fitting of their television aerials to simplify assembly and also impart greater strength. A clamping device is used which by means of a single screw simultaneously locks the elements and secures the fitting to the cross-arm.

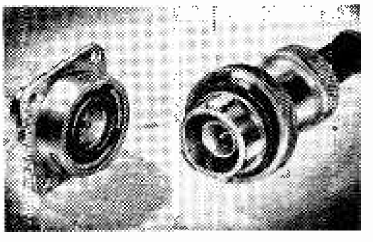
A square-section cross-arm is Wolsey's contribution to the general betterment of aerials. It is claimed to secure the elements more positively, prevent displacement by high wind and also enables the aerial to be part assembled in the factory, thus simplifying the erection on the site.

Antiference have a new indoor television aerial called a "Loftex" for either vertical or horizontal mounting and based on the Antex (X-type) principle. This firm has introduced also a new type of car aerial with a swivelling split-ball base for scuttle mounting at any desired angle of slope. It is telescopic, extends to 62 in and closes to 24 in.

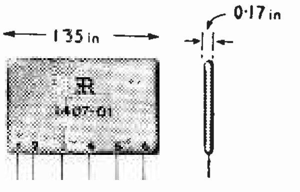
Aerial lenses for the 9-mm wavelength in metal and in plastic were used for an interesting demonstration staged by Marconi's to illustrate some of the characteristics of this type. They varied in size from 6 in to 4 ft in diameter. These lenses are now finding certain applications in relay systems.

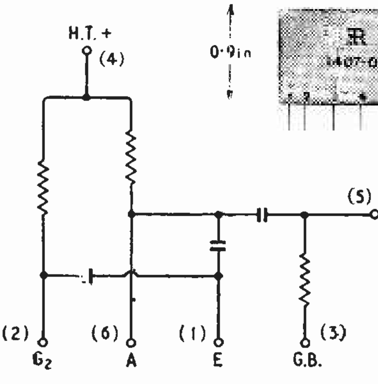
Makers*: Antiference (B, C, T), B.I. Callender's (B, C), Belling-Lee (B, C, T), Henley's (C), Marconi's (S), Reliance Wire (C), Suflex (C), Telcon (C), Transradio (C), Wolsey (C, T).

**Abbreviations:* B = sound broadcast, including anti-interference, C = cables and feeders, S = special types, T = television.



Left: Belling-Lee double-screened coaxial plug and socket.





Erie pentode RC coupler employing printed circuit technique. The circuit is shown also.

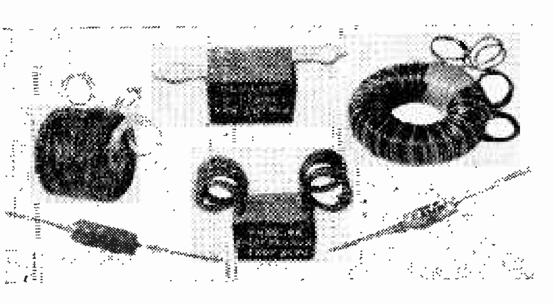
Sub-assemblies

The printed circuit technique is used by Eire in a range of compact resistance-capacitance units covering such requirements as diode filters, triode and pentode RC couplings and various other combinations.

A considerable saving in assembly time can be effected by the use of these units. In one particular case six joints replace some 16 or so if separate components are used.

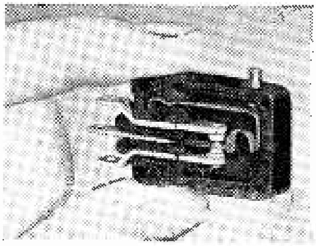
Interference suppressors form another convenient sub-assembly and as produced by Dubilier they comprise capacitors and chokes of one kind or another. A special range of television suppressors is now available for use on or in small domestic appliances such as electric sewing machine motors and hair dryers.

Below: Dubilier television interference suppressors and some of the special chokes now available.



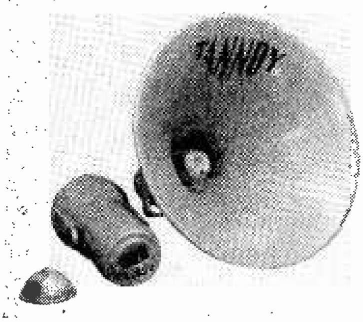
Chassis Fittings

Careful insulation is the main feature of the latest valveholder from McMurdo. Intended for B9A e.h.t. rectifiers, it has a Nylon-loaded Bakelite socket moulded

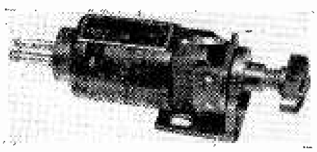


Left: Bulgin micro-switch with side cover-plate removed.

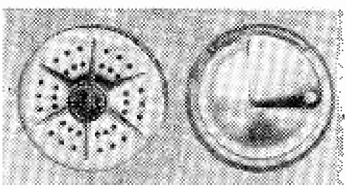
Right: Barrier terminal strip by Carr Fastener.



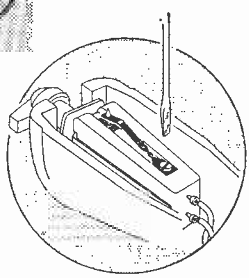
Left: Tannoy 100-watt loudspeaker for airfields, harbours, etc.



Right: Goldring No. 200 magnetic pickup.

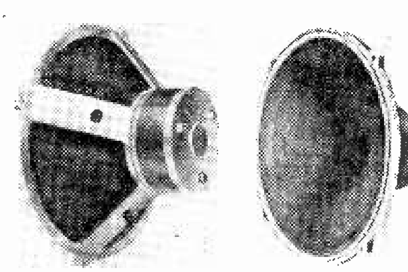


Left: Front and back plates of Acos Mic. 32 microphone capsule.



Right: Collaro "Studio" crystal pickup.

Below: Plessey 15-inch moving-coil loudspeaker.



into a Polythene shroud with an integral Polythene mounting plate, and the safe working voltage to chassis is 25kV. This firm is also producing a quartz crystal socket which will take two types of crystals, those with $\frac{3}{4}$-in pin spacing and those with $\frac{1}{2}$-in spacing.

Belling-Lee have put on the market a very useful double-screened coaxial plug and socket. The contact assemblies are interchangeable in their housings to give either fixed-plug and free-socket or free-plug and fixed-socket, and the two parts are secured by a half-turn locking ring on the housing of the free part. Another improved connecting device is a moulded terminal strip, made by Carr Fastener, with screw terminals on the top face and small insulating barriers separating them. This is claimed to be more reliable than the usual strip containing metal inserts.

The range of cabinet components made by Widney-Dorlec now includes parts for miniature cabinets. These are made on a rather different principle from previous ones and are designed for spot welding. This firm also has a new telescopic mounting for draw-out chassis which locks in two places.

Makers: A.B. Metal Products, Aerialite, Antiference, Belling-Lee, Berco, British Mechanical Productions, British Moulded Plastics, Bulgin, Carr Fastener, Colvern, Cosmocord, Electronic Components, Electrothermal Engineering, G.K.N., Goldring, Hasset & Harper, Hellerman, Igranic, Imhof, Jackson Bros., Long & Hambly, McMurdo, Painton, Plessey, Reslosound, Simmonds Aerocessories, Steatite, Telcon, Thermo-Plastics, T.M.C., Transradio, Tucker Eyelet, United Insulator Co., Walter, Weymouth, Whiteley, Widney-Dorlec, Wimbledon, Wingrove & Rogers, Wireless Telephone Co., Wolsey.

Switches

There was nothing very outstanding in switches this year except that Bulgin have produced a new and smaller version of their well-known micro-switch. Broadly the mechanism is as before (see picture) but it has been made smaller by folding back on itself the spring leaf on which the operating stud presses. Also, the moulded Bakelite body has been made as a flat tablet only $\frac{1}{4}$in thick. The switch can be operated with a pressure of less than an ounce and a movement as small as 5 hundredths of an inch, and will break a current of up to 3 amps.

Makers: A.B. Metal Products, Belling-Lee, Berco, British Mechanical Productions, Bulgin, Diamond H Switches, Electronic Components, Electrothermal Engineering, Erie, N.S.F., Painton, Plessey, T.M.C., Walter, Whiteley, Wearite.

Sound Reproduction

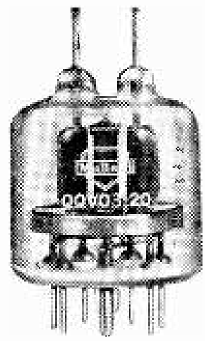
An interesting new p.a. loudspeaker has been developed by Tannoy for airfields, harbours, etc. The single driver unit is rated to handle 10 watts (120 watts peak) and is used in conjunction with a 200-c/s cut-off horn to give an electro-acoustic conversion efficiency of 50 per cent. The pressure unit is waterproof and incorporates a switched transformer for coupling to line impedances of 50, 100, 200 or 330 ohms; the coil impedance is 8 ohms.

Plessey have developed a conventional cone loudspeaker with a power-handling capacity of 25 watts. It is 15 inches in nominal diameter and has applications both as a p.a. unit and as a bass unit in high-quality loudspeaker combinations. Elliptical-type loudspeakers have now been added to the range of "Elac" units made by Electro-Acoustic Industries.

In the new "53" series of Collaro gramophone motors and record changers a new speed-change mechanism with a large-diameter, concentric-ground rubber idler has been designed with a cam mechanism to minimize wear when changing speed. A new crystal turnover pickup head, the "Studio," has been added to the existing Collaro range and incorporates a simple screw fixing for the replaceable cantilever stylus arms.

A turnover pickup working on the moving-iron magnetic principle, giving an output of 0.5V at 3.16 cm/sec lateral velocity has been marketed by Erwin Scharf (Goldring No. 200). The armature is coupled to the stylus by a rubber block in which the cantilever arm is a push fit.

Garrard are now in production with a new transcription-



Above: Mullard double tetrode for use at u.h.f.

Left: Brimar reliable valve with flying leads (equivalent to R18).

type 3-speed turntable (Model 301) in which speed fluctuations are less than 0.2 per cent.

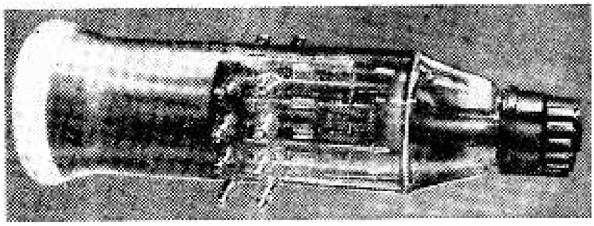
A new crystal microphone of interesting design, the Acos (Cosmocord) Model 32, is of the diaphragm-driven type, and has a flat response up to 6,000 c/s. Cavity resonance is controlled by a specially shaped back plate which reduces volume and compliance of the enclosed air, while the front plate carries a buttressed lug which performs the dual function of providing rigidity and improving the polar response of the microphone.

Makers (Components)*: Birmingham Sound Reproducers (GM, GU, RC, PU); Collaro (GM, GU, RC, PU); Cosmocord (E, M, PU); Ediswan (RC); Electro Acoustic Industries (LS); Garrard (GM, GU, RC, PU); Goodmans (LS, M); Plessey (GM, GU, RC, LS, PU); Reslosound (LS, M); Rola-Celestion (D, LS); Goldring (PU); Tannoy (LS, M); Truvox (LS); Vitavox (LS, M); Whiteley (LS, M).

* *Abbreviations*: D, diaphragms; E, earphones; GM, gramophone motors; GU, gramophone units; RC, record changers; LS, loudspeakers; M, microphones; PU, pickups.

Valves and Cathode Ray Tubes

Sub-miniature valves with indirectly-heated cathodes are quite a new thing in this country. Osram have produced two pentodes, a triode, a beam tetrode and a rectifier of this type, while Mullard have a triode which can be used at frequencies up to 500 Mc/s. In directly-heated sub-miniatures, Mullard are contributing two new hearing-aid pentodes, the DF64 and DL64, designed for 15-V h.t. batteries and with the very low filament consumption of 10mA. Also very economical to run are their new miniature valves for portable battery sets—the filament consumption being only 25mA. Another new miniature battery valve is the Brimar 1AC6 heptode frequency changer, which has an h.t. consumption of only 0.7mA and will operate up to 30 Mc/s. Brimar have also produced an e.h.t. rectifier, the R19, which has the high peak inverse voltage of 25kV, and is enclosed in a lead-glass bulb to prevent radiation of x-rays.



Four-gun oscilloscope c.r. tube made by 20th Century Electronics.

Production of reliable valves is continuing and this year a new range is available from Osram. The valves are mechanically-improved versions of existing Osram types and are known as the "Q" series. Brimar have extended their range of "Trustworthy" reliable valves with equivalents of the 6AM5, 6C4 and R18.

Two transistors of the point type are now available on the British market. These are the Osram GET1 and the S.T.C. LS737, both of which can be used to give a gain of about 20db. New germanium diodes are being made by S.T.C. and Mullard.

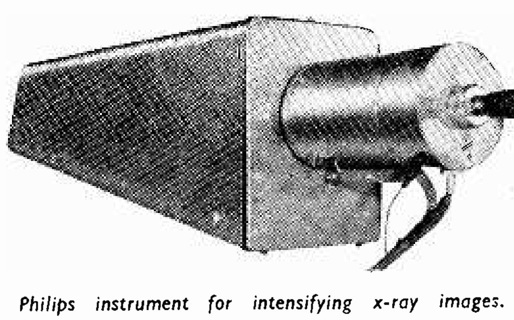
In cathode ray tubes much interest has been aroused by an oscilloscope tube containing four separate guns, made by 20th Century Electronics. It operates at 5kV on the final anode and the deflection sensitivity is just under $\frac{1}{2}$mm per volt. Each gun has independent deflecting plates and the makers claim there is no interaction between them.

Another tube with more electrodes than usual is the Mullard 17-in rectangular television tube MW43-64. This is basically a tetrode, but has an extra electrode between the accelerator and the final anode for improving the uniformity of focus over the whole screen. Like the new Ediswan 15-in tetrode CRM153, this tube has a tinted glass face. Two more tetrodes are being made by Brimar, a 14-in rectangular tube C14FM and a 17-in rectangular tube C17FM.

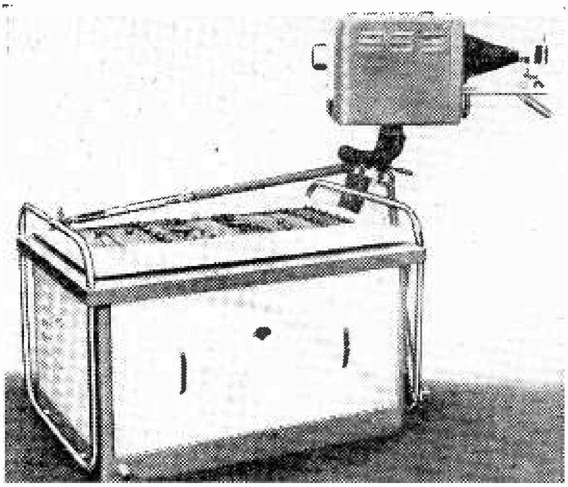
Remarkable for its extremely small size is the Ferranti KD10 voltage stabilizer, which stabilizes at 62 volts ± 0.15 volts with a running current of 1-1.2mA. It is made in a metal capsule measuring only $\frac{7}{8}$in $\times$ $\frac{3}{16}$in $\times$ $\frac{1}{4}$in. Miniaturization is also the main feature of the new Westinghouse tubular e.h.t. rectifiers, Type 39. They are $\frac{3}{16}$in in diameter, and with the selenium elements working at the high P.I.V. of 85 volts they are only 0.6in long per 1,000 volts. The current rating is 100μA and the upper frequency limit 50 kc/s.

ELECTRONIC APPARATUS

The definition of "electronics" concerned with the extension of man's senses was well illustrated this year by three interesting aids to visual observation. One, produced by Philips, is an instrument for intensifying x-ray images so that the radiologist can see them immediately. It works on the image converter principle. The x-ray image is formed on a fluorescent screen and this is in contact with a photo-cathode, which emits a corresponding pattern of electrons. The electrons are accelerated by an electrode carrying a high positive potential and focused on to a second fluorescent screen very much smaller than the first. As a result of this acceleration and reduction



Philips instrument for intensifying x-ray images.



Mullard image converter equipment for high-speed photography.

in size the final image (which is viewed through an eye-piece) is about 1,000 times brighter than the original one.

The second instrument, made by Mullard, uses an image converter tube as an electronic shutter for high-speed photography—the point being that the electron beam in the tube can be interrupted electronically much faster than a light beam can be by a mechanical shutter. In this way exposures can be made as short as 1/20th of a microsecond! The exposure is actually made by applying a positive pulse to a control electrode in the tube, which normally has a negative bias to cut off the electron beam. This produces a brief image on the fluorescent screen which is recorded photographically. Deflector coils enable the instrument to make a line of successive images across the screen so that a cinematographic effect can be obtained.

The third electronic aid to observation is a flying-spot microscope, produced by Cinema-Television. This uses a conventional flying-spot scanning system in conjunction with an optical microscope. The main feature of the instrument is that the image can be displayed on a number of c.r.t. monitors (magnified about 2,000 times) for demonstration purposes. Apart from this, the ability to alter contrast avoids the necessity for staining specimens, while the use of ultra-violet light for scanning gives greater resolving power than is possible with an ordinary microscope (because of the shorter wavelength).

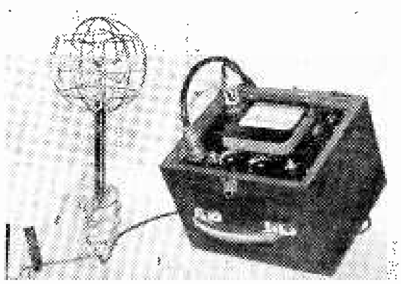
Probably the most original instrument that has appeared recently is the electronic anemometer made by Isotope Developments. It measures wind velocities as low as 10ft per minute. Basically a radiation detector, it uses a wire-cage ionization chamber in which is fixed a small piece of radioactive material. The wind simply blows away the ions which are formed in the chamber and the effect is registered on a meter in the detector.

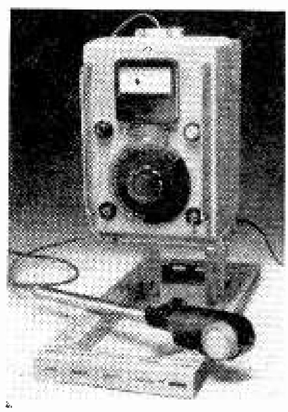
The servo or negative feedback principle is to be seen in a good many electronic instruments nowadays. In several d.c. amplifiers of the mirror-galvanometer type, for example, a portion of the output is fed back to stabilize the action of the galvo. Then in two a.c. voltage regulators a change in input voltage is amplified and applied to a motor, which drives a variable transformer to correct the change. A new pen recorder works on a similar principle with the fluctuations of the d.c. input, the movements of the "correcting" motor being used to drive the pen.

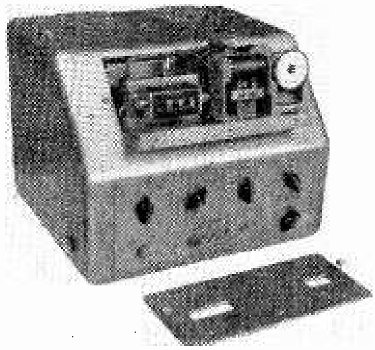
Industrial Electronics

Applications of electronic techniques in industry depend primarily on the measurement of physical constants and the subsequent derivation of signals for automatic control. Sometimes one parameter is obtained in terms of another as in radioactive thickness gauges where the fundamental quantity indicated is mass per unit area of sheet material. In the Baldwin rolling mill extension gauge, thickness is derived in terms of change in length (velocity) of steel strip as it passes through the mill, and the method of measurement is novel. Magnetic recording heads print an alternating pattern of magnetization on the strip before and after rolling, the tracks being offset to avoid interference. Pick-up heads follow the recording heads and their outputs are combined in a differential phase-indicating meter. If the distance between heads before and after the rolls is equal, and if there is no reduction in thickness, the meter reads zero—fluctuations in roll speed are eliminated by driving the recording generator from one of the roll spindles. When there is a reduction in thickness a corresponding increase in wavelength takes place after rolling, and to bring the meter back to zero the "pre-rolling" recording head can be moved relative to its pick-up by a micrometer, which can be calibrated in percentage reduction of thickness. The instrument will detect reductions of less than 0.1 per cent and can be applied to the production of thin steel strip running at speeds of the order of 1,000ft/sec.

B.T.H. have applied a high-speed multiple preselecting batch counter to the measurement of length, and have used it for cutting veneer wood to predetermined lengths. A perforated wheel is driven by the wood strip and interrupts a photo-cell light beam at intervals equivalent to 1/10th inch. Four Dekatron counters in cascade record the passage of the strip, and when the glow reaches the predetermined cathodes in all four tubes, the strip is stopped, cut and the counter reset. Up to ten different lengths can be selected by push-button and this enables the operator to avoid blemishes economically. In practice the measuring speed is limited to 12in/sec, though the counting speed would permit 200in/sec.







Top left: Electronic anemometer by Isotope Developments. Above: Baldwin "Quantex" light quantity meter. Left: Pye direct-reading (counter) pH meter.

Liquid level meters depending on electronic methods are widely used, and in one recent model introduced by Fielden, a self-balancing capacitance bridge technique is used which provides positive indication and control to less than 1 per cent. The principle of the Fielden " Servograph " recorder has been applied by Stanton Instruments to the continuous measurement of weight in a "thermobalance" designed to record the change of weight with time in specimens heated in a small furnace to temperatures up to 1,000 deg. C.

The metering of light quantity is of importance in many photographic and printing processes, and the Baldwin " Quantex " light quantity meter is based on the charging of a capacitor by a current derived from a photoelectric cell. Preset relays give exposures in two ranges covering 1 sec to 1 hour.

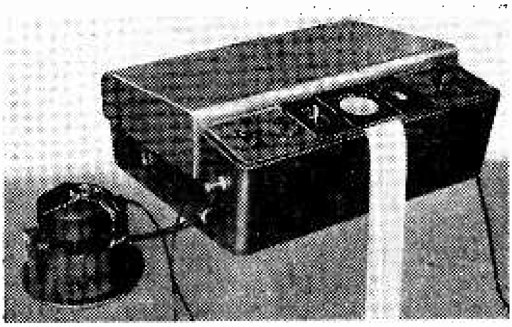
Process timers are widely used and depend usually on the time-constant of an RC circuit. As a demonstration, Allied Electronics show equipment designed to life-test an electronic d.c. voltage stabilizer through a regime of varying load and supply voltage.

Two watch timers are available from Furzehill Laboratories. Type 774V gives a bright spot on a circular c.r.t. trace. The time-base frequency can be varied over a small range to bring the spot to a stationary point, when the error can be read off a calibrated dial. An alternative display expands the watch pulse and provides useful information for the diagnosis of irregularities. In the Type 774E each watch beat is recorded on a strip of paper which records short-term irregularities as well as the average rate. Both instruments make provision for the testing of watches with all standard gear trains giving beats of 3⅓ to 6 per sec.

Developments in strain gauge technique include the production by Saunders Roe of foil elements by a process evolved by Technograph Printed Circuits, Ltd. Considerable simplification of the associated equipment results from the increased current-carrying capacity of these elements. Pressure gauges employing strain gauges are made by Langham Thompson for use in pipe lines and the technique is applied by C. N. Smyth to hypodermic needles for use in medical research.

Ultrasonic flaw detection is now well established and developments are mainly in detail. The latest equipment made by Glass Developments, Ltd., includes barium titanate probes, steerable beam over angles from 90 to 55 deg to the surface, miniature probes for small specimens and a single probe transmitting-receiving technique. C. N. Smyth has introduced an inexpensive flaw detector, with separate or combined transmitting and receiving probes, which can be used as an accessory to a Cossor oscilloscope.

The machining of brittle materials by an ultrasonic technique has been developed by Mullard. A magnetostriction transducer operating at 22 kc/s is coupled by a tapered metal " velocity step-up transformer " to a cutting tip, which, when applied with suitable abrasive, rapidly penetrates glass and other difficult materials. As the motion is translatory rather than rotary, holes and depressions of other than circular shape are easily formed.



Furzehill recording watch timer.

Measurement of pH (hydrogen ion concentration) is important in many industries and a correspondingly wide variety of instruments is available, as exemplified by the small battery-operated portable (Model 30) and the industrial, hermetically-sealed instrument (Model 28) made by Electronic Instruments, for which a wide range of electrode systems is available. The W. G. Pye No. 11082 pH meter gives direct readings on a 4-figure counter with an accuracy of 0.01pH. A self-balancing potentiometer is driven by a servo motor which is also coupled to the counter. Automatic zero correction is carried out continuously while the instrument is idle, so that it is always available for immediate use.

In the "Humicon" humidity detector Standard Telephones make use of glass silk between two perforated plates as a moisture-sensitive impedance. The voltage drop across this is used to control a series of thyratrons which operate appropriate ventilation or heating devices in, for example, a G.C.A. radar mobile van.

The measurement of moisture in coal dust presents difficulties due to variable conductivity from impurities, and the National Coal Board have found that these effects can be eliminated by measuring the effective dielectric constant at 30 Mc/s for which purpose a Fielden "Drimeter" has been adapted.

Dawe Instruments have developed a comprehensive warning system for inflammable gases in the ventilating systems of oil tankers. The principle involved is the rise in temperature and resistance of a catalytic platinum filament. A motor-driven commutator samples all the detectors in sequence and an alarm signal is given on the bridge indicator board by concentrations well below the explosive limit.

TEST AND MEASURING INSTRUMENTS

Under this heading are included instruments intended for laboratory use, for production testing, and for servicing. It is not possible to review any but new or substantially improved models, nor the numerous industrial instruments (many employing electronic techniques) such as material testers, that might conceivably be employed in the radio industry.

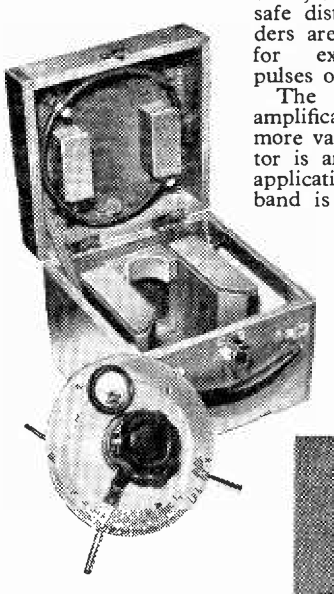
The first impression on surveying the instruments exhibited this year might have been one of disappointment at not finding outstanding new types or techniques. Closer examination would have shown, however, that behind many of the apparently similar front panels a vast amount of real progress has been made. Anyone experienced in the use of instruments knows that small refinements may add up to a more significant total than some striking departure from previous practice.

Even the old-established moving-coil meter has not reached the limit of improvement, and this year there seems to be more evidence of this than usual. To obtain a high sensitivity and speed of response, Everett Edgcumbe use four high-flux magnets in the magnetic circuit, which is shaped so as to allow a 270-degree scale instead of the usual 120 degrees. In the Metrovick meters an exceptionally robust result is achieved by skilful use of die castings and mouldings. Ballistic characteristics are especially important in signal level indicators, and the new Pullin VU meter, which is a rectifier m.c. voltmeter, claims to reach 99 per cent of steady value in about 0.3 sec, with an overswing not more than 1.5 per cent. Another specialized m.c. instrument is the Pye fluxmeter, full-scale reading 700,000 "line-turns" (7 milliweber-turns), in the well-known " Scalamp " format; provision is included for rapidly restoring the deflection to zero. A portable silicon-crystal millivoltmeter developed by A.I.D. for testing signal-generator output calibration might well find wider applications on account of its frequency range of 1-300 Mc/s. An attenuator has been designed which extends its voltage range (0.05-0.15).

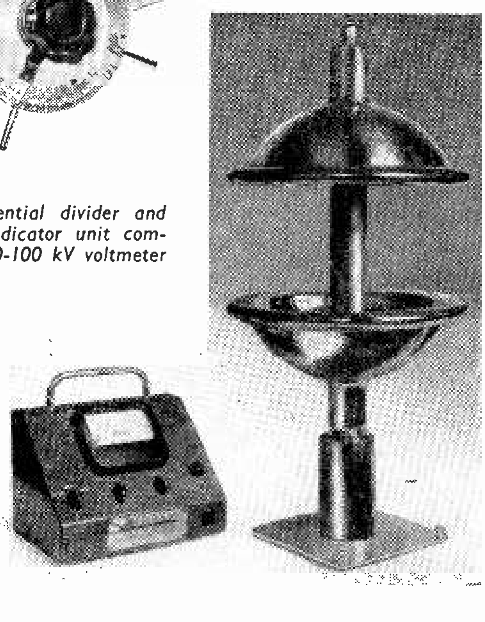
Among valve-aided meters the most noticeable trend is the use of pre-detector wide-band amplification to increase sensitivity, as in those by Dawe and Furzehill. The ranges of the latter (Type V.200) are now 1mV-1kV full-scale, and the frequency coverage—10 c/s-6 Mc/s—is adequate for high-definition v.f. work. The Philips 6010 battery-powered millivoltmeter, for zero frequency, employs the modulation principle so as to amplify stably over twelve ranges, 0.1mV-300V, with input resistance 0.67-100 MΩ; with the addition of a probe containing a germanium rectifier it can be used for measuring voltages from 5-1,000 mV over the wide frequency range 2-800 Mc/s. Very high input resistance is now becoming common in z.f. valve voltmeters; an instrument shown by B.T.-H. is exceptional in having an input current of only 0.1 micromicroamp at frequencies from zero to 100 kc/s.

Measurement of very high voltages is a problem. The latest Ernest Turner electrostatic voltmeters up to 20 kV are protected against brush discharge by the use of fixed vanes of graphite-loaded Bakelite. At still higher voltages, safety is a major consideration. A capacitive potential divider by Hivolt uses a concentrated field around the periphery to protect the divider proper (arranged axially) from proximity effects; the indicator, connected by a long cable, can be read at an amply safe distance. Capacitive dividers are also made by B.T.-H. for examining high-voltage pulses on a c.r. oscilloscope.

The facilities of wide-band amplification are perhaps even more valuable when the indicator is an oscilloscope. In this application, width of frequency band is usually appreciated as speed of response. Amplifiers are obtainable separately from Nagard and Cossor, working from z.f. or thereabouts upwards, but for examining high-speed transients there are obvious advantages in having the amplifier built into the oscilloscope. Several new models are well adapted for this type of work, notably the Nagard DG.103 with double-beam tube, the Philips GM.5660 with frequency band 15 c/s-10 Mc/s and pulse rise time 40 mμs, and the Airmec 830 (30 c/s-20 Mc/s and 25 mμs respectively). The notable sharpness and brightness of the trace on the screen of the last-named oscilloscope is maintained even at the extreme speed of 30 cm per μsec. Philips also have a new oscilloscope which, although a general-purpose model, takes into account the importance of pulse technique in television. It is notable for including two identical amplifiers covering 0.3 c/s-1 Mc/s and exceptional synchronization facilities. There are several other new general-purpose oscilloscopes. The Cossor 1052 also has two identical amplifiers and other improvements on the old 339, but does not include voltage-calibrated shifts like the 1049; a separate voltage calibrator (1433) is obtainable however. The Furzehill 1684D/2 continues and extends the association of this marque with direct-coupled amplification, the frequency range now being 0-4 Mc/s. The Industrial Electronics 2300, although a truly miniature 2½in-tube instrument weighing only 6¼ pounds, includes features usually obtainable only in types many times its size—push-pull amplification from zero to 100 kc/s on both X and Y plates, and automatic synchronization.



U.h.f. absorption frequency meter, Type TF. 1026/1 (Marconi Instruments).



Field potential divider and remote indicator unit comprising 20-100 kV voltmeter (Hivolt).

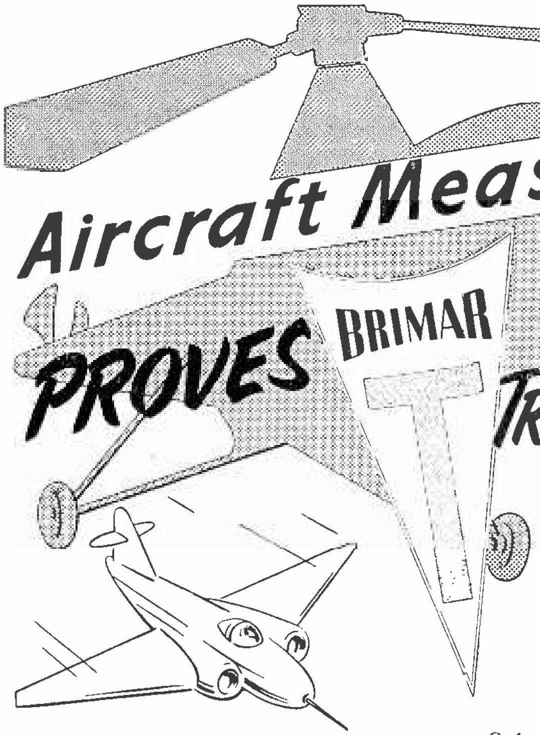
The Advance range of signal generators has been extended in the 15 c/s-50 kc/s band by Type J, which differs from the H.1 in having a calibrated power output up to 1 watt at a constant 600-Ω impedance, rather than a voltage output. Two varieties are obtainable, with and without output meter. There is now a smaller version of the Dawe a.f. source. The previous Muirhead decade oscillator has been superseded by an improved model having remarkable frequency accuracy.

All of these employ RC tuning, which has displaced the beat method for a.f. purposes, but where a very wide frequency is required without switching the beat method still applies, as exemplified in the interesting Philips GM.2889 a.m.-f.m. oscillator, covering 5-225 Mc/s in one sweep. It is particularly suitable for measuring bandpass response of television and other receivers; f.m. at mains frequency can be obtained with deviation up to 10 Mc/s by means of a "loudspeaker" movement. For testing discriminator characteristics, 400 c/s f.m. is available up to 250 kc/s deviation. A separate 15-30 Mc/s oscillator is incorporated for introducing frequency marker "pips."

The Marconi Instruments TF948 signal generator covers 20-80 Mc/s in two ranges, the effective scale length being over 14 feet, and is provided with sine wave f.m. and sine and square wave a.m., internally at three audio frequencies. The specification is elaborate and includes crystal frequency checking and modulation depth and deviation measurement. Another new instrument from the same firm is the v.h.f. test set TF.982, comprising a signal generator for 60-184 Mc/s and four i.f. ranges, a crystal calibrator, a r.f. field detector, an a.f. output power meter, and a multi-range test meter. A range of frequency hitherto not at all well provided for—300-1,000 Mc/s—is covered by the Advance L.1 signal generator in two ranges, using a 6F4 valve in a conventional series-tuned oscillator circuit. Output is controlled over a 130db range by a piston waveguide attenuator, and modulation can be either sine or pulse.

Instruments for frequency measurement are not so prominent as they have been in times past, but there are three new Furzehill crystal frequency standards; one providing 150 watts at 50 ± 10^{-5} c/s, and two portable units for general frequency checking, of which Type G.410 is provided with push-button control for selecting standard frequency signals at multiples of 0.1, 1, 10, 100, 1,000 and 5,000 kc/s. A vastly more elaborate equipment is the Plessey frequency synthesizer, which now appears with motor-driven operation by which any multiple of 1 kc/s up to 100 Mc/s can be automatically selected. An unusual

Aircraft Measuring Equipment PROVES BRIMAR TRUSTWORTHY VALVES



Two years of rigorous testing have proved beyond doubt, that, under extreme conditions in the Services and Industry, Brimar Trustworthy types maintain a high standard of reliability and efficiency under conditions where ordinary production types fail. Here is an example :

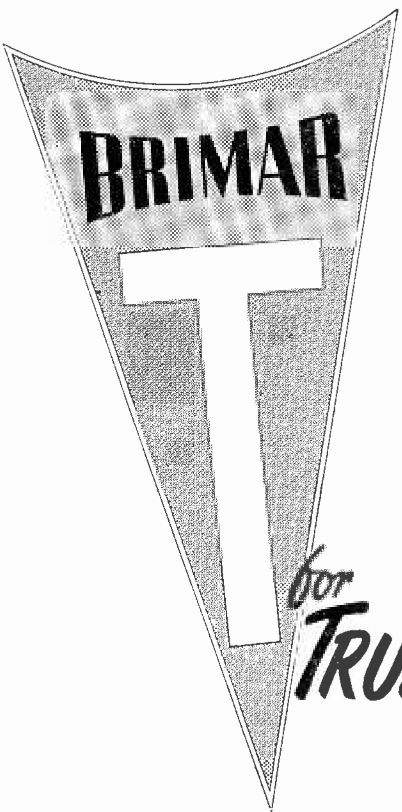
In order to investigate the stresses of helicopter motor blades, a D.C. amplifier was installed in the motor head, transmitting signal levels to the control cabin below.

The excessive vibration rendered normal valves useless, and reduced the valve life to only a few minutes.

Substitution of Brimar " Trustworthy " type 6067 freed the D.C. Signals of all noise, and measurements were able to proceed.

In another case, an Aircraft Company required instrumentation to measure stresses on jet aircraft when approaching the speed of sound. This equipment consisted of sensitive amplifiers located in the aircraft. Normal valves were too noisy under these conditions to give reliable results, but modification, to employ Trustworthy valves, has since solved the problem. Further, the equipment has stood up for a considerable number of hours service under these arduous conditions.

These are but two of many examples which prove that extra-rugged, extra-reliable Trustworthy valves are so often the perfect solution to an otherwise insoluble problem.



3 TRUSTWORTHY types are immediately available for commercial use

6064	the Trustworthy version of	CV138	(6AM6/8D3)
6065	,, ,, ,, ,,	CV131	(9D6)
6058	,, ,, ,, ,,	CV140	(6AL5)

for TRUSTWORTHY

BRITISH MADE

BRIMAR VALVES

Standard Telephones and Cables Limited **FOOTSCRAY, SIDCUP, KENT**

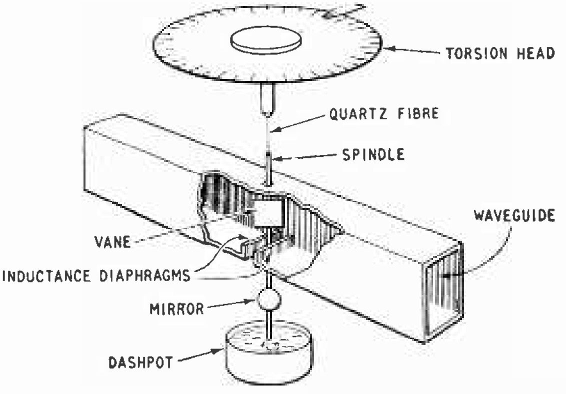
form of absorption frequency meter (TF.1026 series), illustrating an entirely different conception of frequency measurement, has been introduced by Marconi Instruments; each has a 2:1 frequency ratio, the whole series of five covering 125-4,000 Mc/s. The resonant system comprises a coaxial line closed at one end and tuned at the other by a variable capacitance.

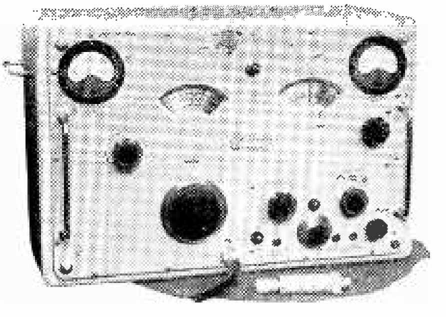
Nearly all new a.c. bridge designs, for all frequencies from power to v.h.f., are based on the use of transformer ratio arms for input or output or both. One of the chief advantages is that an admittance connected across part of a low-leakage transformer winding does not appreciably alter the ratio, as it would if connected across one of a pair of resistance ratio arms. As a result, the values of components can be measured *in situ*, notwithstanding that relatively low admittances exist between both terminals and earth. An example is the grid-to-anode capacitance of a screened valve, which is small absolutely and also relatively to the capacitances to cathode, etc. Wayne Kerr have for some time been exponents of this technique for high r.f., and now have several experimental models for a.f. In one, capacitances can be measured from 12,000 pF down to 0.0001 pF, at 10 kc/s. A 1-Mc/s transformer bridge devoted more particularly to inter-electrode capacitances and conductances and therefore less wide in range has been produced by Electronic Tubes. It is worth noting that in both these bridges, as well as in other high-performance modern equipment, the humble "magic eye" is adequate as the indicator. In another experimental Wayne Kerr bridge the Maxwell form is brought up to date with a transformer output, 10 kc/s source, and "magic eye," to such good effect that self and mutual inductance are measurable in ranges as low as 0.01 μH full-scale. But perhaps the most interesting of the series is a 1-kc/s bridge for four-terminal network measurements, in which full use is made of transformer arms to cover all four quadrants of the complex plane.

If one terminal of a bridge arm is joined to its screen, as in most of these obtainable separately, its use is thereby limited. For adaptability it is necessary to have two screens, the outer earthed and the inner joined to the arm; decade resistance boxes so arranged are produced by the Croydon Precision Instrument Company.

Apparatus for displaying valve characteristics on a c.r. tube screen now appears in a form adapted for germanium valves (transistors), by Marconi's W.T. Co. The development of equipment for testing the mechanical properties of valves has been stimulated by the requirement for valves to stand severe conditions, such as being shot from guns. The usual technique is to vibrate the valves by a modified loudspeaker drive and to examine them mechanically and electrically. In the set-up by Electronic Tubes the movements of the electrodes can be seen stroboscopically, and their resonance spectrum recorded photographically from electrical responses. The observing instrument in the Industrial Electronics vibrator equipment is the c.r. panoramic wave analyzer by the same firm.

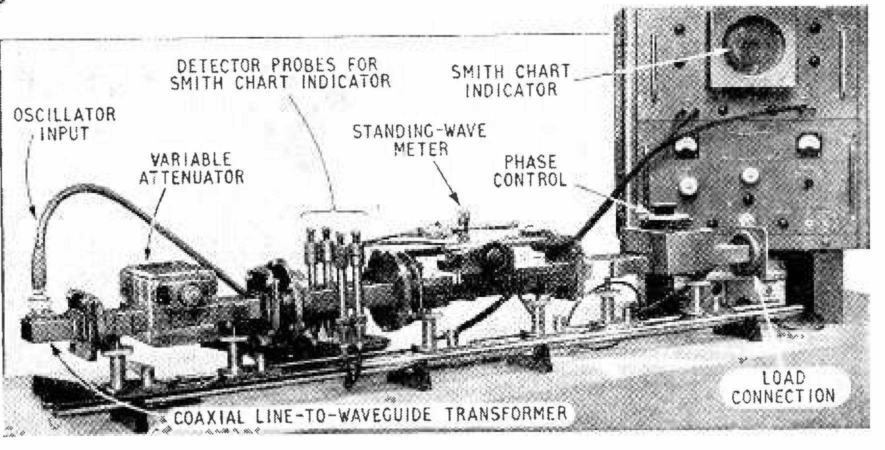
Measuring apparatus for frequencies over 2,000 Mc/s centres on the waveguide "test bench" assembled from a wide variety of waveguide sections and components. Most of the work is based on observance of standing-wave ratio and node positions, and some recent devices have the object of facilitating this. In the Decca automatic s.w.r. indicator four crystal detectors mounted in the waveguide and spaced at eighth-wave intervals are connected to a c.r. unit which provides a display in Smith chart form from which the frequency variation of a match can be seen at once. A cylindrical chart enabling displacements measured at one frequency to be seen by inspection for any other frequency in the waveband has been devised by the Admiralty. Among the precision microwave instruments offered by Elliott Bros. is a torque vane wattmeter for absolute measurements of power in the X band. The vane is suspended by a fine quartz fibre at 45 degrees in the waveguide, and the power passing along the guide is measured in terms of the mechanical torque exerted on the vane. This can hardly fail to remind one of the Raleigh disc absolute method of measuring sound intensity.





Above: Torque vane wattmeter, for absolute measurements of power in the X (3-cm) band (Elliott Bros.).

Above, right: U.h.f. (300-1,000 Mc/s) standard signal generator, Type L.1 (Advance Components).



Right: Microwave test bench, fitted with spaced detectors for automatic Smith chart display on the indicator seen on the right (Decca Radar).

TRANSISTORS

By THOMAS RODDAM

5—*Applications in Trigger Circuits*

EARLIER articles in this series have dealt rather generally with the nature of the two common forms of transistor and with some of the more elementary linear circuit properties. Following the plan of the series, which is to hop from topic to topic in an effort to cover an enormous field sometime in the foreseeable future, we must now look at the applications of transistors to trigger or switching circuits. Here the future is wide open and, from some points of view, rather depressing. As an example of a transistor application here, I have two blocking oscillator circuits performing equivalent functions, one using a valve, power consumption 1 watt, and a transformer, as well as the few resistors and capacitors ; the other uses a transistor, three resistors and one capacitor, and consumes only 50 mW. Apart from the difference in bulk and power consumption, the smaller unit should operate in the particular application for ever, while the valve must have its heater operating continuously, so we can expect to change valves at least once a year.

I say this is rather depressing, because it makes the fully automatic factory a much more immediate prospect. As Norbert Wiener has pointed out, we shall then have a community supported by slaves, a state of affairs which can be studied better in Gibbon than in the works of the economists. This may happen quite quickly, and our only hope is to make sure that the first computing machine can be solving the economic problems faster than the industrial machines are creating them. I do not think we shall get much guidance from either the Georgics or from "Das Kapital." But make no mistake, within 10 years or so we shall see the development of two economies, transistorized and non-transistorized, and if we are to belong to the second class we might as well start planting cabbages now.

The trigger circuit is the key item of any digital device. It produces pulses, re-shapes pulses, accepts them, rejects them. In most existing computer systems a twin-triode circuit has been used, but now the single or double transistor circuits are sweeping the board. Let us consider the general properties of these trigger circuits.

The equations given earlier in parts 2 and 3 of this series showed that the impedances presented at the input or output terminals of a transistor-resistor circuit could be negative, provided that the current gain, α, of the transistor was greater than unity. At the present time we can take this to mean that a point transistor must be used. This negative resistance is the first requirement for obtaining the type of

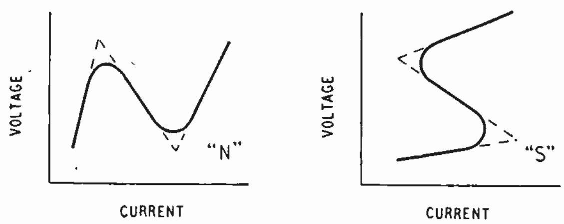
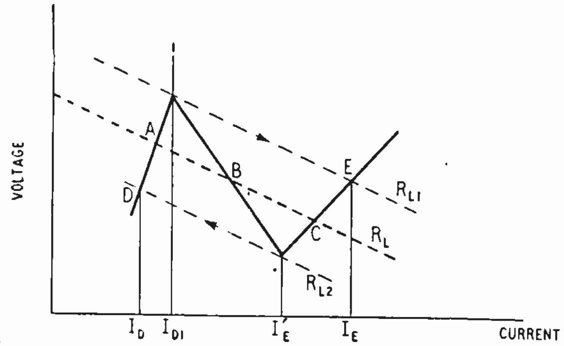


Fig. 1. Characteristics of the two main types of negative resistance.

Fig. 2. N-type negative resistance with load lines. Intersections like B are unstable.



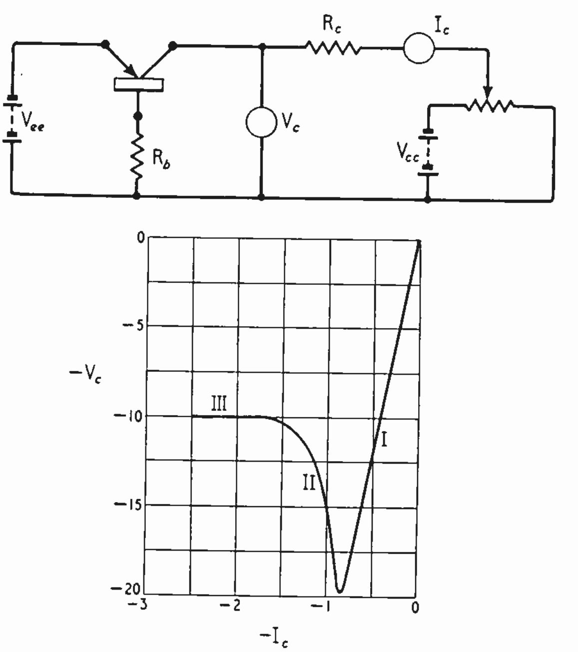
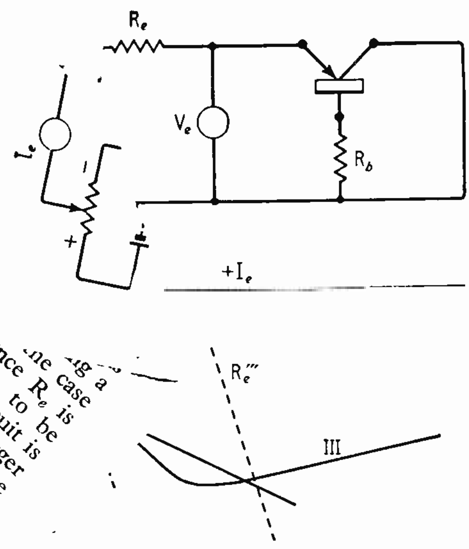


Fig. 3. Collector large-signal negative-resistance characteristic.



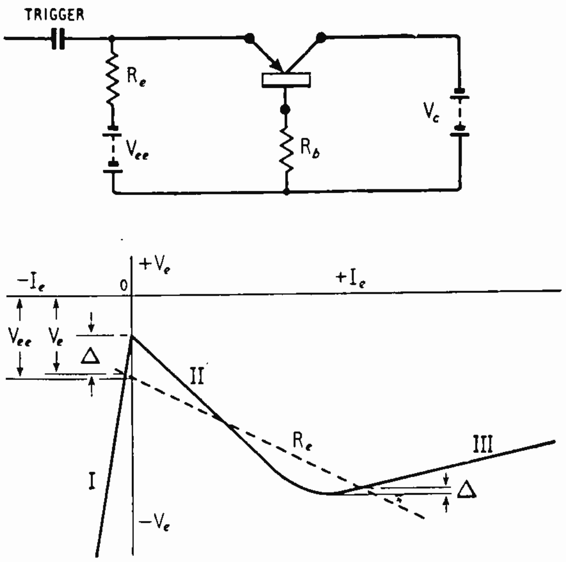


Fig. 4. Idealized emitter large-signal negative-resistance characteristic. Right : Fig. 5. Bistable transistor circuit.

...n-linear operation which is nowadays called a "switching function." A general investigation of these "switching functions" leads to the view that the most rational method of analysis is obtained by splitting the action into three regions : on, off, and transition. The classic example of such a system is the famous Duke of York, who had 10,000 men (when they were up, they were up . . .). All the important switching functions used in engineering contain some sort of energy storage which drives the circuit through the transition region. A very simple example is the ordinary press type of electric light switch. As you press the button you store energy in a spring until a triggering threshold is reached, when the spring drives the mechanism from one position to the other.

There are two types of negative-resistance characteristic, and it is necessary to be clear which type we are using in any particular circuit. The reason why there are two types is only understood when the full impedance diagram is plotted, because it depends on the way the impedance behaves at the extremes of high and low frequency. This is a topic for an article in itself. Here we can content ourselves with the voltage-current diagrams of what are called, for obvious reasons, the N and S types of negative resistance. Fig. 1 shows the simplified forms of these diagrams. The N type of negative resistance is stable when open-circuited, but is not stable when short-circuited: the S type is short-circuit stable, but unstable when open-circuited. A rough picture of the difference between the two is obtained by considering some conventional oscillator circuits, in which the tuned circuit may be either resonant, if the negative resistance is short-circuit unstable, or anti-resonant, if the negative resistance is open-circuit unstable.

Let us consider what happens if we have an N-type negative resistance and we connect a positive load resistance R to the terminals. Since the N characteristic is the characteristic of an active network we must put a bias battery in the circuit, too. The load line can then be moved parallel to itself, and three possible positions are shown in Fig. 2. The middle position, marked R_L is the most interesting. It intersects the N at three points, of which A and C correspond simply to two positive resistances in series and are thus stable. At B we have a loop consisting of a negative resistance in series with a numerically smaller positive resistance. This is unstable, and if the system is moved to B by some means it will snap (as fast as the reactances in the circuit will allow) to either A or C.

Now suppose that the system is stable at A and we alter the bias to move the load line up to R_{L1}. The only stable point is E, and the current through the loop jumps smartly from I_{D1} to I_E. Now we change the bias in the opposite direction, to bring the load line down to R_{L2}. The current falls slightly to I'_E and then as the load line leaves the right-hand corner the current drops to I_D as the only stable point becomes D. This sort of snap action will be familiar to anyone who has ever used the Schmitt double-triode trigger circuit.

It does not require much imagination to see that a load line can be imposed on the S-type characteristic in Fig. 1 to give three-point intersection. All the discussion in the last paragraph can be rewritten with the word current replacing voltage and vice-versa and it will then apply to the S-type characteristic. These two characteristics are, in fact, duals. The subject of duality has been explored by "Cathode Ray," and will be discussed in detail later.

Switching Circuits

Now, perhaps, we can turn our attention to transistor circuits. In Fig. 3 and 4, we have two very simple test circuits and the voltage-current characteristics obtained with them. In Fig. 3, the circuit is held under control by using a large value of R_c so that the tests can be carried out even in the negative resistance region II. The same stabilizing function for the emitter characteristic of Fig. 4 is performed by R_e. Both these curves belong to the N-type, although region III has got flattened out a bit : but regions I and III are positive resistance regions, linked by the negative resistance region II.

Fig. 5 shows the simple transistor bistable circuit.

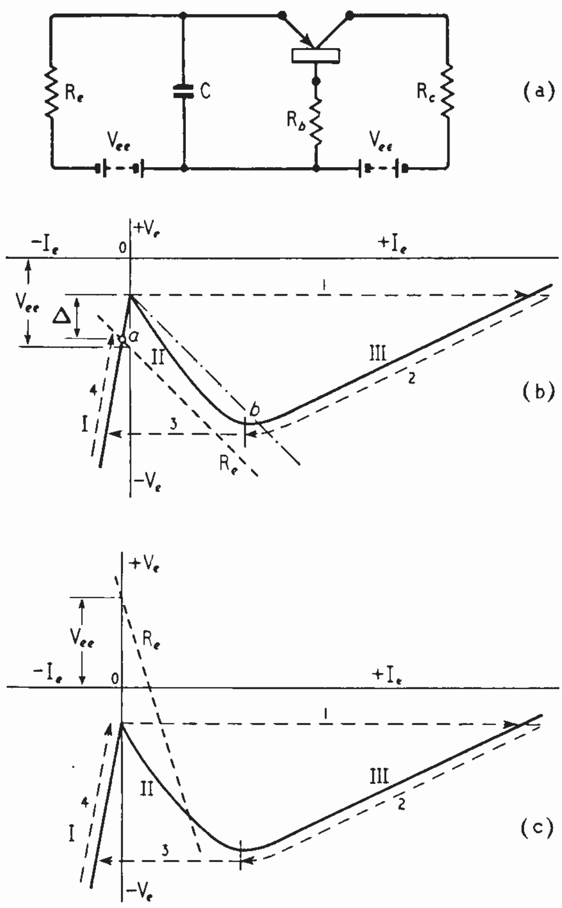


Fig. 6. Monostable and astable characteristics resulting from the addition of capacitor C.

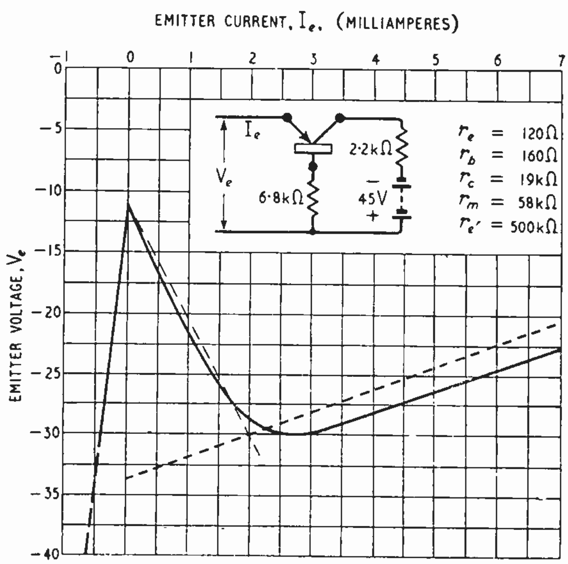


Fig. 7. Basic circuit values and calculated (dotted) and measured emitter negative resistance characteristics, for a Type 1698 point transistor.

If you compare the characterist[...] you will see that there are two [...] the system can be triggered from [...] applying a pulse of the right polar[...] input. This circuit is equivalent [...] resistance-coupled multivibrator u[...]

[ic with that of Fig. 2, stable positions, and one to the other]

Having this idea of the multivibra[...] let us see how we can introduce ca[...] transistor circuit to convert it to either a[...] "single-shot" multivibrator. A single[...] been introduced in the circuit shown [...] Fig. 6. The extra resistance R_c is fairly [...] introduced to provide a convenient way [...] low impedance output from the circuit. [...] shown in Fig. 6(b), the controlling resis[...] low enough for the three-point intersec[...] possible. The value of V_{ee} is such that th[...] normally stable at *a*. Suppose now we put in [...] voltage △. The load line is lifted up to the ape[...] N-curve, and can then "see" the single stable p[...] As soon as the system starts to re-set itself to *b*, how[...] the capacitor C presents a short-circuit to the emit[...] and the operating point jumps along the line 1 t[...] high emitter current. When the intersection with th[...] N-curve is reached, however, R_e takes control again and the capacitor starts to discharge along the path 2. By this time, however, the trigger pulse has ended, and when the discharge brings the emitter voltage to the trough, the working point jumps along the short-circuit line 3 to meet region I again. Finally, the emitter voltage runs up along 4 to the point *a*, where the system waits for a new trigger.

With a higher value of R_e and positive bias applied to the emitter we have the conditions shown in Fig. 6(c). This arrangement is astable, as the only intersection is in region II. The circuit oscillates steadily round the path 1, 2, 3, 4.

Pulse Length and Spacing

Practical values for a circuit of this kind are shown in Fig. 7 for a 1698 point transistor. With the values given in the inset diagram and an emitter load resistance of 15,600 ohms returned to the earth line, frequencies of 2,000-10,000 pulses/second and pulse lengths of 20-2,000 microseconds can be obtained with capacitors in the region 0.01-0.5μF. Both experimentally and theoretically it can be shown that pulse length and spacing are proportional to capacitance. Experimentally I have found that pulse repetition rate is fairly linear with emitter bias. The characteristic in Fig. 7 is not extended far enough to enable the peak emitter current to be determined, but a rough estimate is about 12 mA. The pulse available at the collector will be about 40 volts. When very short pulses at repetition rates of the order of 1,000 pulses/second are needed, the most satisfactory arrangement seems to be to use an emitter load resistance of the order of one megohm, and a correspondingly smaller capacitance. The 40-volt output pulse can then be obtained with collector current of about 1-2 mA, but for reliable operation a positive bias voltage on the emitter is needed to lift the intersection clear of the corner.

More elaborate circuits of this basic kind for bi-stable operation incorporate diodes in the base or emitter circuit. I hope we shall be able to consider these in more detail later, but for the moment we may note that one form of this arrangement converts the R_e line into a "dog leg," and provides a more certain three-point intersection condition.

A very similar discussion will apply to the arrangements shown in Fig. 8. The N-type collector characteristic enables us to arrange for bistable, monostable or astable working. There is nothing of special interest here, unless it is the danger of excessive currents with the low emitter impedance.

The base connection is rather more interesting. The voltage-current plot shown in Fig. 9(a) on the following page is of the S-type and it can be seen that one condition for the three-point intersection load line is that the external base load resistance must be numerically larger than the negative input impedance. By inserting inductance in the base lead we get the instantaneous open-circuit effect, corresponding to the capacitance short-circuit, needed to give the snap action in monostable and astable action. The circuits and conditions are shown in Figs. 9(b) and 9(c), and in any practical circuit a resistance in the collector lead would be added to provide an output. The main disadvantage, of course, is the rather limited range of time constants available using inductances.

This treatment is obviously of great value in considering sinusoidal oscillators. If the capacitor in the emitter or collector astable circuit is replaced by a resonant circuit, the system will act as a sinusoidal generator, limited by overloading. Similarly, the inductance in the base circuit can be replaced by an anti-resonant circuit. The design problem is quite easy now. Looking at Fig. 7 we see that the emitter circuit resistance can be just over 9,000 ohms and the emitter bias −10 volts to give a barely astable condition with the other values as shown. The net negative resistance is then very small, so that oscillations will be limited without much overloading.

Refinements of the simple emitter circuit, the most commonly used form, are directed towards improving the pulse shape. With the simple capacitor circuit the collector current pulse has a drooping top caused by the run down path 2 (see Fig. 6). The capacitor can be replaced by an open-circuited delay network, of the ordinary pulse-forming type. This has two results: the pulse top becomes flat, and the pulse duration no longer depends on the time constant (C × emitter resistance), but is fixed by the line. Different samples of transistor give identical pulses. The second refinement is to use diodes in the monostable circuit, so that it takes the form shown in Fig. 10. This circuit is triggered by a negative pulse applied to the base. Once the trigger action starts, the diode CD2 cuts off the input terminal so that it has no further control over the action. As a result, the output pulse is practically independent, both in width and amplitude, of the input trigger. The other diode, CD1, is provided to reduce the time constant of the capacitor discharge in section 4 of the path. This means that the circuit returns very quickly to its quiescent position after producing a pulse, and very high repetition rates are possible. This circuit is used in computers to reform the pulses after they have passed through the various gates. Obviously it could also be used as a repeater in a pulse code modulation system.

Another application of diodes is in stabilizing the position of the junction between regions I and II. In the characteristic shown in Fig. 7 this junction is at 11.5 volts. The value can be calculated, and is approximately $V_cR_b/(R_b + r_c)$, where V_c is the collector voltage, R_b the total base resistance and r_c the collector resistance. The weak point is r_c, which varies with temperature. Typical figures suggest that the junction

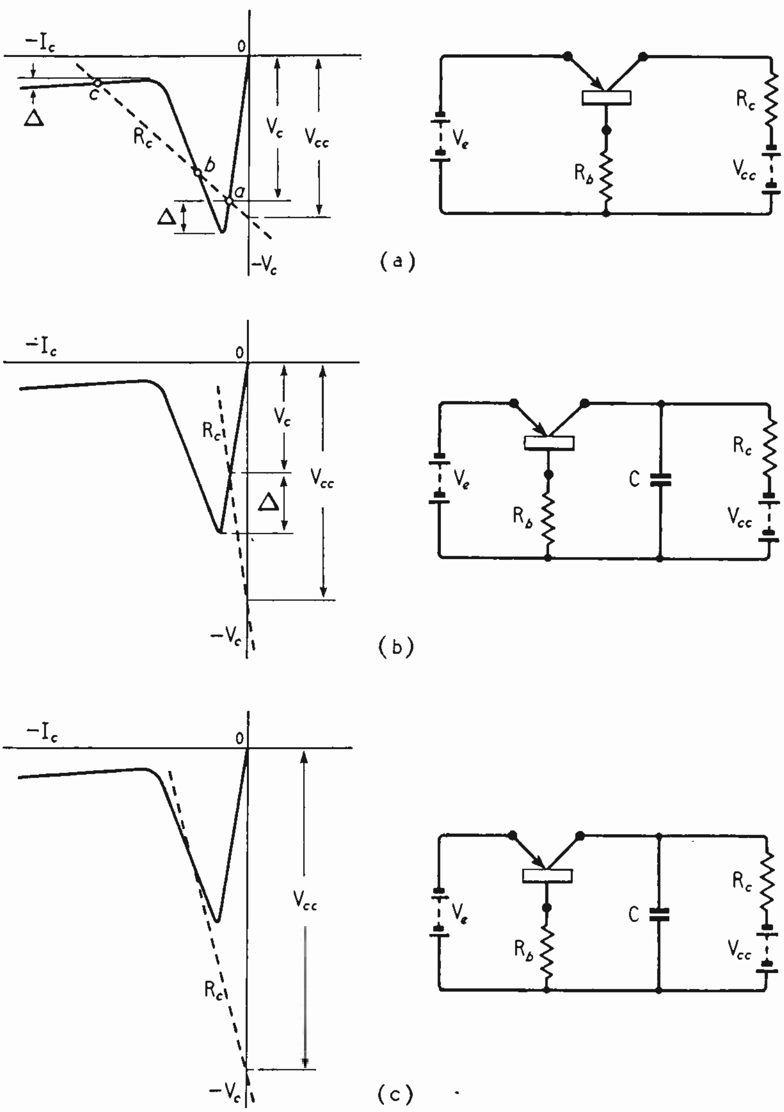


Fig. 8. Collector-connection switching circuits.

may move about 5 per cent, or, say, 0.5 volts. For circuits adjusted to maximum sensitivity this is rather important, especially if the transistor moves into the bistable condition and locks on.

I do not propose to discuss the actual circuits used to prevent this until some later date. A word of warning is perhaps the best conclusion: in using these circuits, always make sure that they will fail safe and that if an oscillator or monostable circuit does lock on it will not allow a destructive current to flow. Inductive loads are especially dangerous in trigger circuit working because they slow down the passage through the region in which the transistor has a large dissipation.

Acknowledgment.—Figs 3 to 9 are based on Figs. 3, 4, 6, 7, 20, 9 and 11 respectively of " Transistors in Switching Circuits " by A. E. Anderson and Fig. 10 on Fig. 16(a) of " Transistor Trigger Circuits " by A. W. Lo. Both papers appeared in *Proc. I.R.E.*, Vol. 40, No. 11, Nov. 1952.

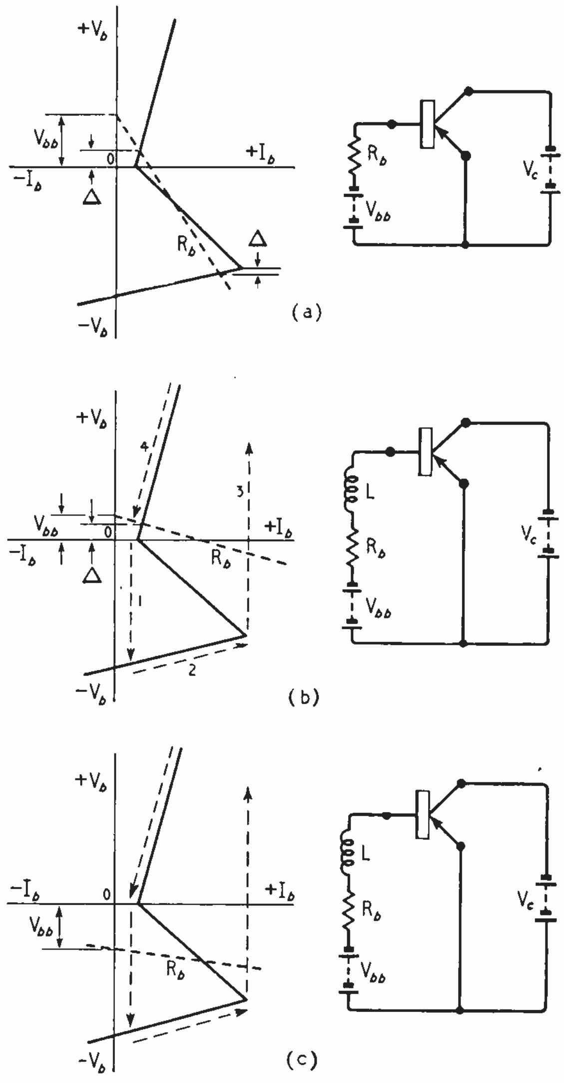


Fig. 9. Base connection switching circuits.

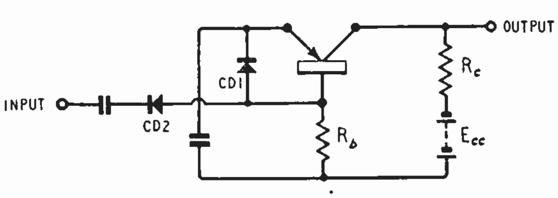


Fig. 10. Addition of diodes to stabilize pulse width and amplitude.

Manufacturers' Literature

Metal Rectifiers; a brochure giving dimensions and weights of selenium spindle-mounted stacks, with an explanation of the coding system used to identify them. From Standard Telephones and Cables, Rectifier Division, Warwick Road, Boreham Wood, Herts.

Solder, in wire, pellet and fluid form; a leaflet giving a summary of the products of Multicore Solders, Hemel Hempstead, Herts.

Television Receiver, type TUG36; console with a 17-in tube giving a picture 14in × 10½in and with five controls on the front panel, described in a leaflet from Bush Radio, Power Road, Chiswick, London, W.4

Radio-gramophone, H.M.V. model 1617A, with ten waveband ranges, three-speed record changer and 8-watt output from a 13½-in speaker. Circuit description and specification in a leaflet from the Gramophone Company, Blyth Road, Hayes, Middlesex.

Universal Television Servicing Unit (" Klempt " Type FW0200), comprising a versatile a.m./f.m. signal generator and oscilloscope. Technical specification leaflet from Otto Gruoner, Winterbach bei Stuttgart, Germany.

High-energy Permanent Magnets using " Columax," an improved grade of " Alcomax III," and claimed to have the highest magnetic energy per unit of volume yet achieved (8.63×10^6 gauss-oersteds max.). Specification and curves in a leaflet from Swift Levick & Sons, Clarence Steel Works, Sheffield, 4.

Electro-mechanical Devices, including a.c. and d.c. relays, mercury relays, time-delay relays, solenoids, thermostats and low-inertia motors for instruments. Specifications and operating characteristics in a catalogue from Electro Methods, Caxton Way, Stevenage, Herts.

Anti-vibration Instrument Mountings, in stud form, made of rubber with projecting metal pins. A leaflet giving shapes and sizes available from Howard Clayton-Wright, Wellesbourne, Warwickshire.

Television Converters; alignment instructions for Type AC/4 units in a leaflet from Spencer-West, Quay Works, Great Yarmouth, Norfolk.

Surplus Equipment, Government and manufacturers', listed in a catalogue from Clydesdale Supply Co., 2, Bridge Street, Glasgow, C.5. Also a supplementary list of **Components and Accessories.**

Microwave Test Equipment, for waveguide sizes 10 and 11, including standing-wave meters, adjustable short circuits, matched loads, waveguide-to-coaxial line transformers, variable attenuators, waveguide bench rails and supports, and a Heil-tube test oscillator. Loose-leaf book containing specifications from Decca Radar, 1-3, Brixton Road, London, S.W.9.

Toggle Switches and Signal Lamps, also a number of special-purpose switches, described in an illustrated catalogue with blue-print drawings from Arcolectric Switches, Central Avenue, West Molesey, Surrey.

" Permanent Magnets," a well-produced illustrated book of 58 pages covering the theory of magnetism, design of magnets, materials used, properties of various alloys (with curves and tables), effects of heat, shock and alternating fields, magnetizing and demagnetizing, testing, storage and handling; with a glossary of technical terms. From the Permanent Magnet Association, 301, Glossop Road, Sheffield, 10, price 10s.

Waveform Analyser; description and specification (with curves) of the Muirhead-Pametrada instrument and associated equipment, with notes on its use for vibration measurement and waveform analysis in various industries. An illustrated booklet from Muirhead & Co., Beckenham, Kent. Also a leaflet on their amplifier-maintained tuning forks for frequencies of 480-2,000c/s.

THE "BELLING-LEE" PAGE

Providing technical information, service and advice in relation to our products and the suppression of electrical interference.

Gold Plated Components

Considerable interest was aroused by the gold plated contacts on several of our components on view at the recent R.E.C.M.F. exhibition.

This finish came about as a result of stringent tests to which many components under development for the Ministry of Supply and Admiralty are subjected.

These tests, particularly those of R.C.S.11, to which components of the H.1 grading have to be submitted, include subjection to temperatures of 100°C dry heat, where hitherto the top temperature in many cases was only 70°C. In addition, there are tests in which the components are exposed to exacting and prolonged conditions of damp heat.

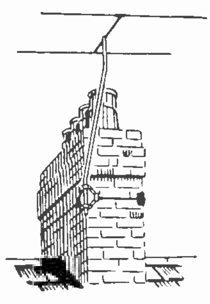
To maintain a low contact resistance under the exhaustive tests described above, considerable attention had to be given to the contact surfaces. After intensive investigation it was found that a gold flash on an appropriate underfinish gave the required durability, together with low contact resistance.

It will be obvious that once the process had been introduced, its benefits would be applied wherever desirable.

It may be asked why not keep to silver? Silver discolours badly as silver sulphide has an awful appearance, and makes it very difficult for soldering.

Birds on the Aerial

When speaking to an audience in a district where horizontal aerials are necessary, one question certain to be asked is, "What



happens if a row of seagulls decide to perch on the elements?" Web-footed birds **don't** perch in the accepted meaning of the term. They will sit in rows on the comparatively rounded apex of a roof, or on the flat "bun finial" of a flag pole, but they cannot grasp a half-inch rod or tube. Starlings might, but they only weigh a few ounces. We have seen rooks that have developed a technique of grasping the top of an "H" aerial, and sitting apparently in comfort, but even a rook has little weight. Birds are built for lightness, even their bones are hollow and contain air.

Suppression of Household Appliances

A few days ago we were testing out a new flex lead suppressor on a number of appliances, hair-dryers of various makes, fans, sewing machine motors, etc. The tests were carried out at home. When tried with T.V. on an outdoor aerial, suppression was quite good, making all the difference between intolerable nuisance and entertainment value. On an indoor aerial in the same room as the receiver however, interference was still troublesome. That is why, as we have so often written before, the authorities will have scant sympathy for a complaining viewer who has not done his best for himself by the erection of an aerial suitable for his location.

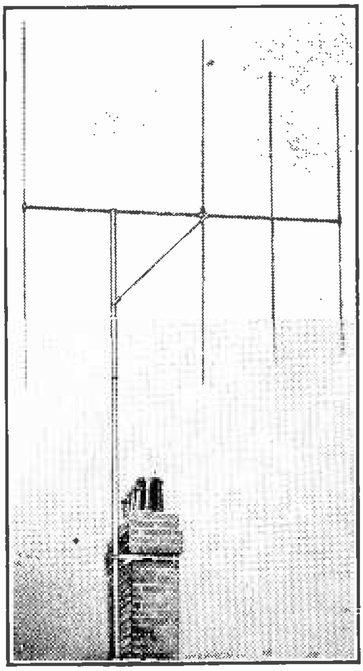
A Lightning Tip

A few peals of thunder at Easter reminds us to issue the annual soother regarding lightning. The chance of a strike on your house is very remote, and the presence of an aerial does not increase the risk. If anything, it is bound to reduce the chance, as the presence of the aerial connected to a receiver is constantly discharging that little pocket of air in the immediate vicinity, thereby reducing the voltage gradient.

We can pass on a useful tip for those who feel they should do something to satisfy a qualm. Theoretically, the top element should be connected to the centre conductor of a co-axial feeder and the lower to the screen. We doubt if the average user would notice the difference, therefore reverse the arrangement and take the upper element to the screen, and before it enters the house, remove the P.V.C. outer covering exposing the screen, twist round it a length of heavy copper wire and take to a good earth by the most direct route. Care should be taken to waterproof the join with adhesive tape, otherwise water might syphon into the house via the screening mesh.

"Non-Directional" "Multirod"

We had a report from a useful source, that a "Multirod," carefully installed, was apparently "all round looking." The case was sufficiently interesting to warrant sending the mobile research laboratory to examine the situation. We found that the answer was due to the fact that the site was surrounded by hills, there was



"Belling-Lee" "Multirod" 4-element array.

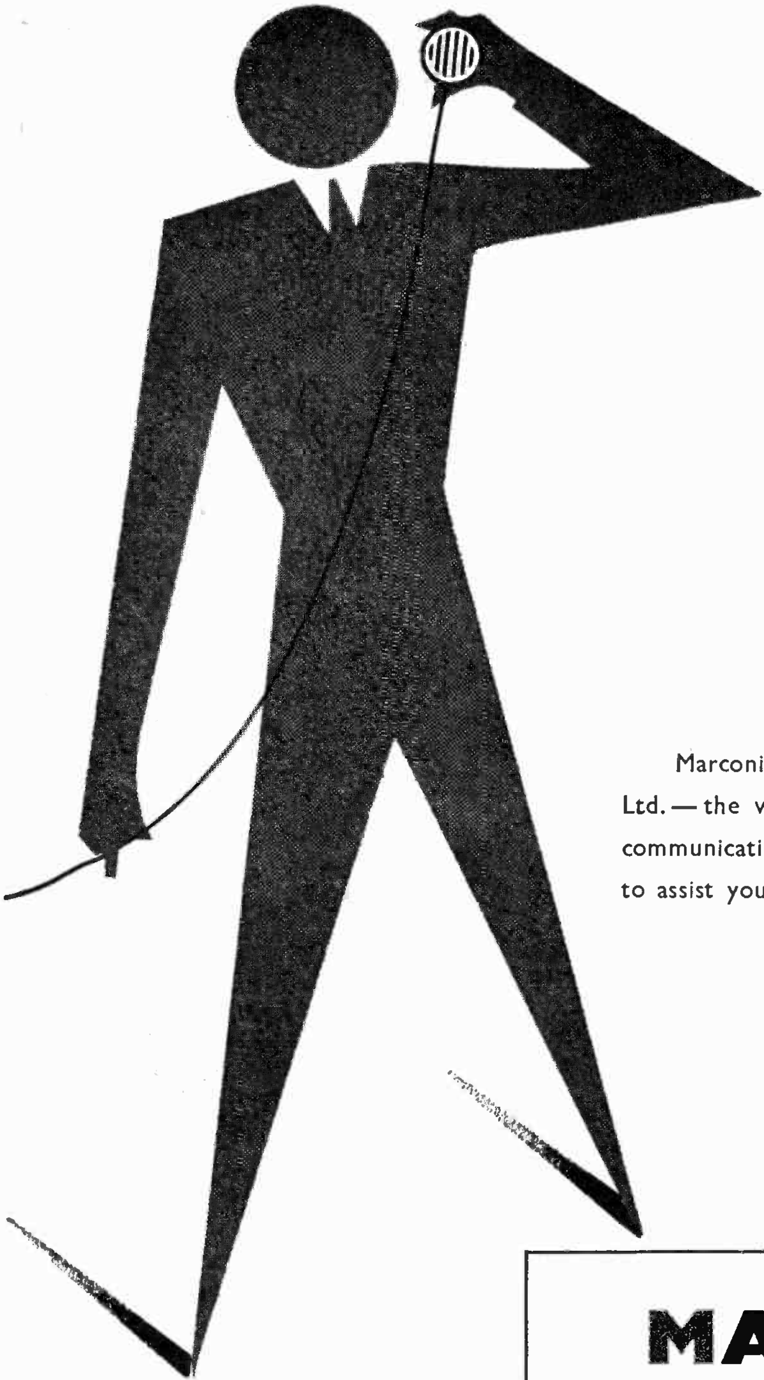
apparently no direct signal, all that the aerial received was reflections and diffusions from the high ground.

Aluminium Corrosion

Most forms of corrosion are very serious to the engineer, and we would prefer to think that there was no such thing associated with our aerials. We ask users to paint aerials on erection and at intervals, but we know that few are so treated. The form that aluminium alloy corrosion takes, is that parts tend to "grow" together, with a reduction of electrical resistance.

Written 27th April, 1953

BELLING & LEE LTD
CAMBRIDGE ARTERIAL RD., ENFIELD, MIDDX., ENGLAND



Diagnosis of Distortion

By E. R. WIGAN*
B.Sc.(Eng.), A.M.I.E.E.

The "Difference Diagram" and Its Interpretation

AT the outset it should be emphasized that this article is not concerned with the *measurement* of distortion; it deals with a method of *diagnosis* aimed at recognizing, locating and removing the source of any distortion which is found.

The diagnosis is made by examining an oscilloscope trace which represents all the defects of the apparatus which is being tested. By comparing the outline of this picture with certain standard shapes, examples of which are given here, the various sources of distortion can be recognized. For example, typical overload conditions can be recognized at a glance (Figs. 10 and 11). In other photographs the distortion conditions have been artificially exaggerated to bring out the characteristic features.

The technique adopted to generate these pictures can be summarized briefly as follows:—

A pure sine wave signal is applied to the test object (an amplifier, for example) and also to the X-plates (horizontal axis) of an oscilloscope.

The distorted output signal is applied to the Y-plates after passing through a network which subtracts the pure fundamental wave and leaves only the distortion terms, together with any hum, hum-modulation or circuit "noise." Before being applied to the Y-plates this "difference" signal is amplified, generally 30 to 100 times.

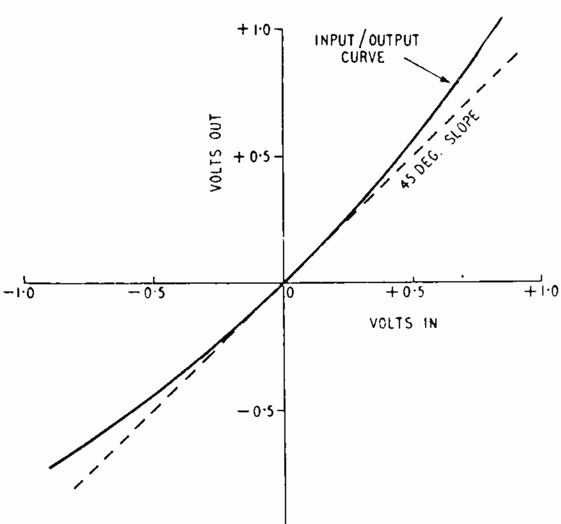
When the phase of the X-signal is suitably adjusted the trace shown on the oscilloscope closes into a curved line which is a representation of the transfer characteristic of the circuit tested with all its defects enormously magnified (see Figs. 1 and 2). Because this display is produced by a subtraction process the term "difference diagram" has been chosen for it.

The technique has the special merit that transient or slowly changing distortion conditions can be observed. Moreover, although it is not put forward as a measuring technique, it is possible to read off from the difference diagram the magnitude of the primary distortion terms with useful accuracy, a procedure which is necessary when correlation with standard harmonic analyses is required.

Since distortion components as small as 0.1 per cent can be recognized under good conditions, this method of diagnosis is applicable to amplifiers, oscillators, and the like, which have to meet even the most stringent performance specifications.

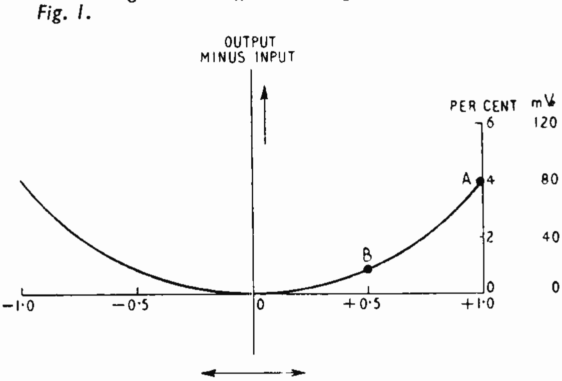
The equipment required is relatively simple and can be assembled from apparatus generally available in an audio-frequency laboratory.

Details of Apparatus. To understand the difference diagram, consider first the typical input/output transfer characteristic of a single-valve amplifier shown in Fig. 1. The curve for an ideal amplifier is represented by the dotted line with a slope of 45 degrees, and the difference (i.e., vertical intercept) between these two curves represents the departure of the system from the ideal conditions. In Fig. 2 this difference is shown, plotted in the form which has been called the difference diagram.



Left: Fig. 1. Ideal (dotted) and actual transfer characteristic of an amplifier.

Below: Fig. 2. "Difference diagram" corresponding to Fig. 1.



* B.B.C. Research Department.

The block schematic of the apparatus to produce this diagram electronically is shown in Fig. 3. The two upper branches carry out, at (9), the subtraction process illustrated in Figs. 1 and 2. The fourth branch is used only when a large distortion term has to be cancelled to prevent confusion of the fine detail.

The circuits shown are arranged for a test frequency of 1,000c/s. The filter (8) in Fig. 3 is necessary only if the phase shifter (7) contains valves which may introduce distortion. The ganged attenuators (4) and (6) are used to alter the input level to the test object (5) without changing the output level delivered by (6).

If it is desired to cancel any selected component in the difference signal, the oscillator (15), which can be set to multiples of 1,000c/s, is locked to the input signal by a "spike" generated by clipping and differentiation at (14). Element (12) is used to adjust the phase of the harmonic frequency generated by (15) relative to the phase of the test signal.

The arrangement shown in Fig. 3 is used when both the pure input signal and the distorted output signal from the test object are available, but if this is not so, and only the output can be obtained, the arrangement of Fig. 4 is employed.

Since the signal equivalent to the missing input signal is necessary for the "subtraction" process, a filter (8) is employed to abstract a pure sine wave from the output signal. Tests of this kind are called here 2-terminal tests, to distinguish them from the 4-terminal test made when both input and output terminals can be used.

Typical Diagrams. Essentially the difference diagram is a Lissajous figure, the configuration of which will change with the setting of the phase control of the X-amplifier. In some circumstances it follows the shape of the transfer characteristics and it may also be used, with caution, to estimate the harmonic content. To introduce the reader to the kind of information which a difference diagram yields the following examples have been chosen: Fig. 5(a) is the difference diagram generated by a single-valve output stage. The input/output curve of such a stage is similar to Fig. 1, so the diagram of Fig. 5(a) resembles Fig. 2. When the input voltage is increased the diagram changes to Fig. 5(b) The downward "spike" on the right is due to grid-current which sets in fairly sharply and reduces the output voltage. (The reason for the curve being looped is dealt with in the Appendix.)

The input/output curve of a push-pull stage is like Fig. 1 in the upper part, but in the lower part lies below the dotted line. As a result the difference diagram (see Fig. 6) droops downwards on the left-hand side and tips up on the right.

The distortion component present in Figs. 2 and 5(a) is almost pure second harmonic, shown by the two positive maxima in the difference signal. Fig. 6, however, shows nearly pure third harmonic because there are three positive maxima in the trace on the tube; one on the extreme right, one as the fundamental approaches negative maximum, and one as it returns to the centre again. In this photograph the "go" and "return" traces are, of course, superimposed. The vertical width of the diagram is due to hum in the amplifier. In spite of this the upper and lower edges retain their characteristic S-shape.

The flattened parabola of Fig. 7 indicates a heavily driven triode stage and contains both second and third harmonics. It consists of a parabola (characteristic of second harmonic) to which has been added an S-shaped curve which steepens one end and flattens the other. The relative proportions of the two components can be deduced from this. Here again, in spite of a very large proportion of hum, the upper and lower edges of the diagram retain the shape characteristic of the non-linearity of the system. To get this photograph the earlier stages of the amplifier were heavily driven while the gain control at the input to the final stage was turned down.

Fig. 8 shows the presence of hum-modulation in a push-pull output stage in which there was a strong 100-c/s ripple in the h.t. supply. The test-frequency was set to be exactly ten times the ripple frequency so that ten individual stationary traces could be seen, each corresponding to a different h.t. voltage. Each trace, Fig. 8(a), is a distorted S-shape and oscillates 100 times per second about the centre point of the

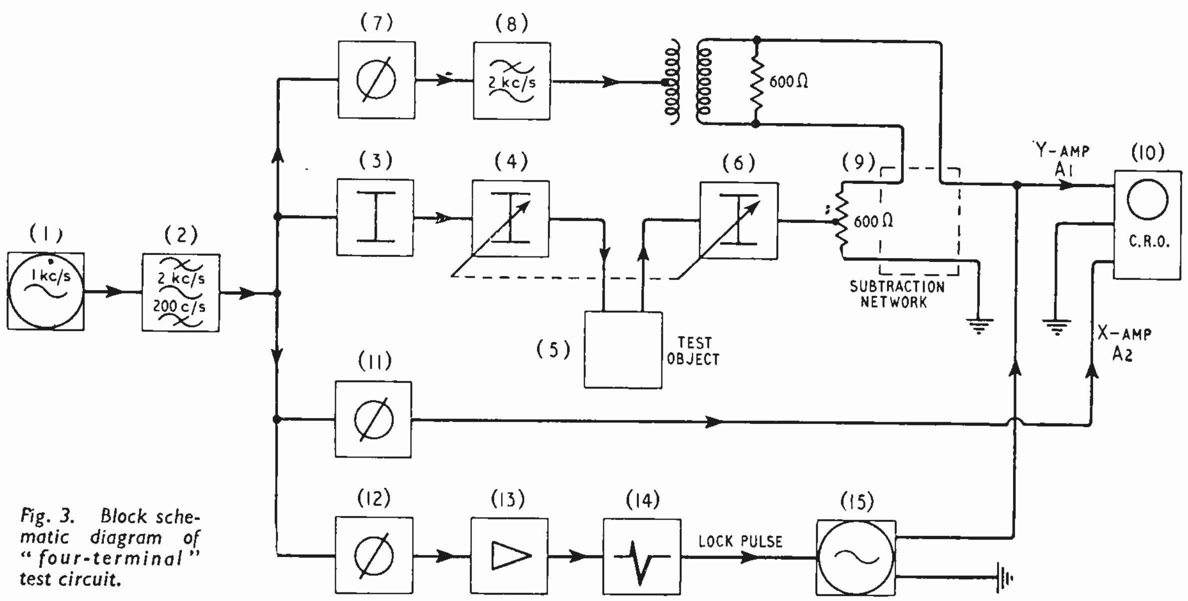
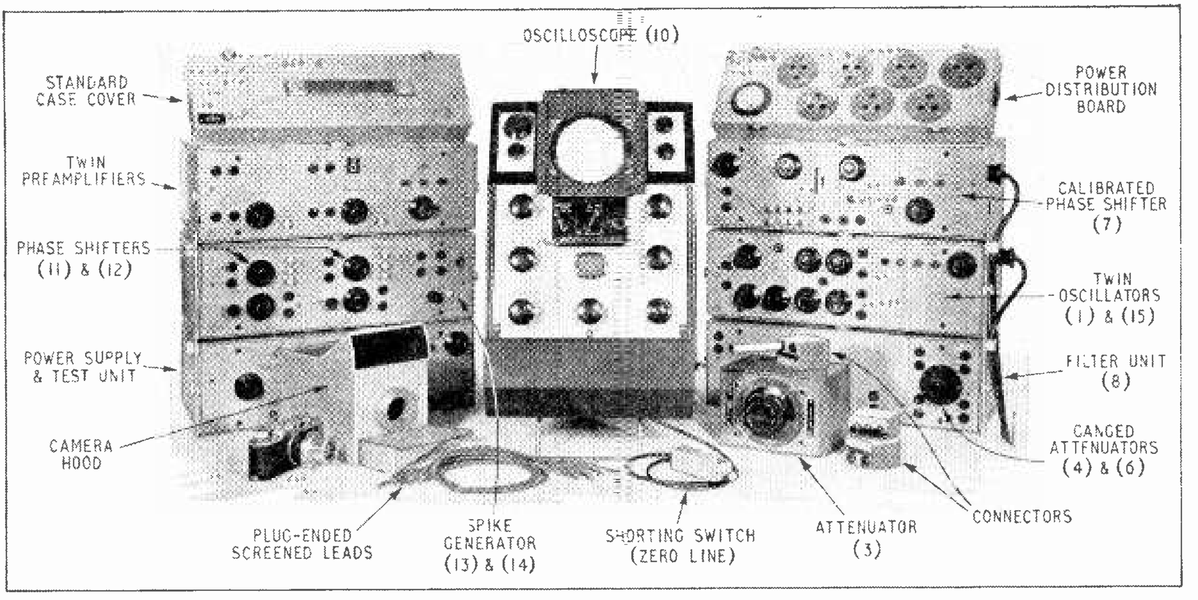


Fig. 3. Block schematic diagram of "four-terminal" test circuit.



Portable test equipment and accessories. Numbering corresponds to that used in Figs. 3 and 4. The twin pre-amplifiers on the left are used to provide either high-level test signals (up to 20 dbm) or to act as a buffer between the output from the test object and the input to the test gear. All units are housed in the standard ventilated boxes used by the B.B.C. Research Dept. for portable test apparatus.

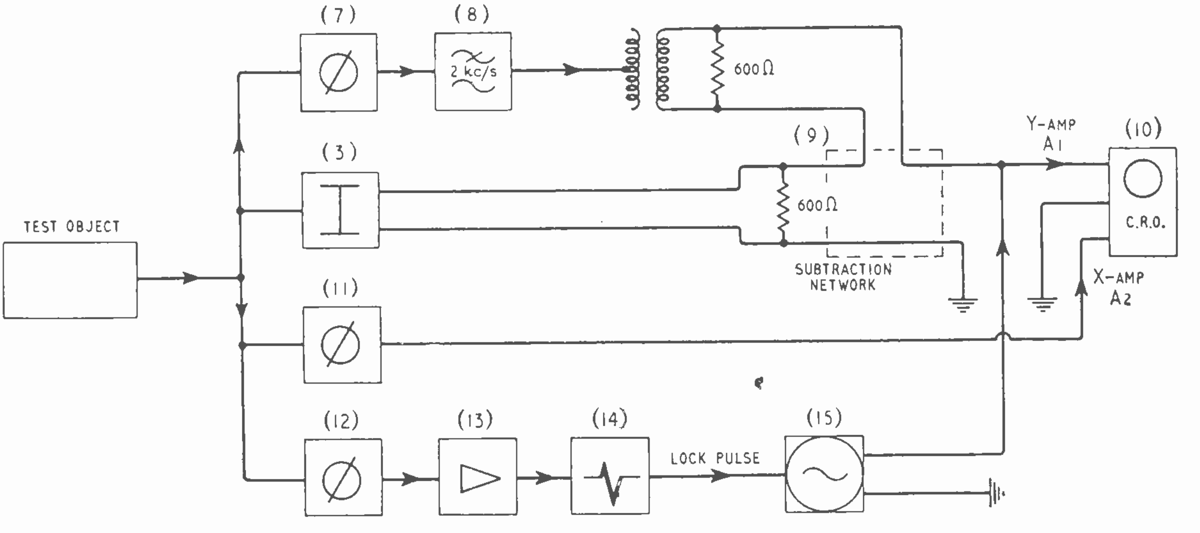


Fig. 4. " Two-terminal " circuit for use when the input to the apparatus under test is inaccessible.

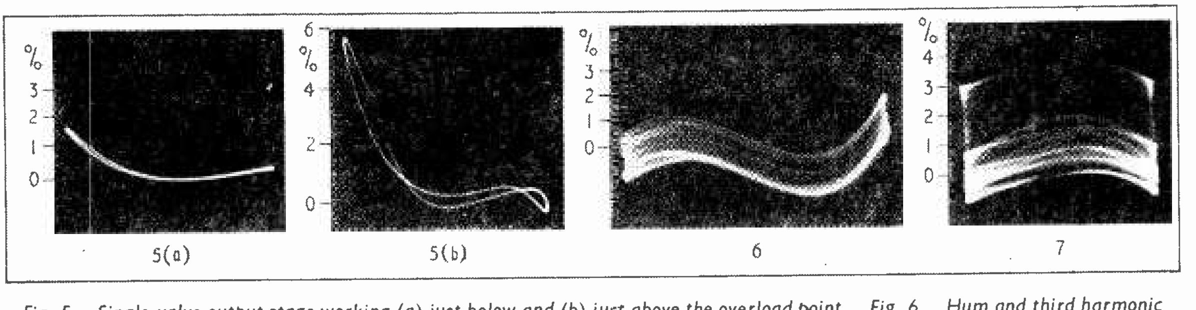


Fig. 5. Single-valve output stage working (a) just below and (b) just above the overload point. Fig. 6. Hum and third harmonic in a push-pull output stage. Fig. 7. Hum at greater level than second and third harmonics (single-valve output stage).

diagram. When the driver stage was balanced the second harmonic term disappeared, yielding Fig. 8(b). Finally the third harmonic was removed by "injection" (see Appendix). The resulting diagram, Fig. 8(c), has nearly straight edges which shows that higher distortion terms were negligible, evidence that the system was operating well within its capacity.

The previous example illustrates very well how effective a picture of the distortion can be, for the amplifier in question had earlier been tested with a wave analyser. The 100-c/s modulation had not then been noted, whereas the diagram showed at a glance that the modulation term was several times larger than the second or third harmonic.

Figs. 9(a), (b) and (c) show gross distortion in an amplifier of the electro-mechanical type in which a moving-iron loudspeaker movement drives a pair of push-pull carbon buttons. There are some novel features. Fig. 9(a) shows the stepwise response of the carbon granules. Fig. 9(b) shows a double line at bottom centre due to an alternative transient condition. Figs. 9(c) and (d) show an unsuspected phenomenon, the reversal of the phase of the distortion terms when the d.c. voltage fed to the carbon button was increased slowly through a critical value. The distortion, Fig. 9(c), momentarily disappeared and reappeared in reversed phase, as shown in Fig. 9(d). It will be noted that the "go" and "return" traces are different, owing to friction or other forces between the carbon granules.

The remaining diagrams were obtained with the circuit of Fig. 4. Figs. 10 and 11 show the "spike" characteristic of a system driven beyond its designed limits. Figs. 12(a) and (b) show very clearly the sharp origin distortion produced by a diode. The loop in Fig. 12(b) generally appears when severe overload is associated with a large transient phase shift.

The distortion illustrated in Figs. 11 and 12 is the result of two processes, and neither diagram alone gives any clue to the true cause. Both the recording and the playback equipment combine to produce Fig. 11, and transmitter and receiver combine to produce Figs. 12(a) and (b). From a series of diagrams representing different carrier levels and degrees of modulation it is, however, possible to separate the influence of the receiver from that of the transmitter, but it is difficult to find an equivalent method of dealing with recording distortion.

Fig. 11 is a good example of a difference diagram containing "noise" which has blurred the edges of the trace. Variation of the speed of the turntable caused slight oscillations of this diagram about its centre point. This has slightly lengthened the extremes of the trace and confused details which could be clearly distinguished when the diagram was directly viewed on the tube face.

Scale of the Diagram. The Y co-ordinate (i.e., the height) of any difference diagram will depend directly upon the gain chosen for the Y-amplifier of the oscilloscope. This gain must be known and included in any photograph of the diagram either for record purposes or to allow one picture to be compared with another. If the procedure set out below is followed the photograph is like Fig. 12(b). The necessary information is given by the scale.

The percentages represent the deviation from linearity of the transfer characteristic; the scale must be used with caution, however, for it can be applied directly only to the extremities of the diagram (e.g., the point A in Fig. 2). At that point the percentage scale reads 4 per cent while the input voltage is 2.0 V peak-to-peak. It follows that the 4 per cent ordinate corresponds to 80 mV. That is to say that if the conventional transfer characteristic were drawn, the instantaneous output voltage would exceed the instantaneous input voltage by 80 mV where the latter was +1.0 volt. Observe, however, that the corresponding ordinate at −1.0 volt input indicates that at this point on the diagram the output voltage will be less than the input voltage by 80 mV. This follows from the simultaneous change of sign of input and output voltage as the left-hand side of the diagram is entered.

This apparent anomaly should be carefully noted, and in practice a test always has to be made to establish whether positive or negative ordinates on the tube face represent gains or losses. A simple test is to apply a biased-off diode to the test-circuit; where the signal voltage exceeds the bias a sharp kink or spike appears in the diagram. The direction of this spike indicates the loss ordinate.

Suppose now that the diagram of Fig. 2 were used to predict what the distortion would be if the signal input were reduced from 2 volts to 1 volt peak-to-peak. The diagram of Fig. 2 would then terminate at B. The mV scale shows that the error voltages would be 20 mV; i.e., 2 per cent of the input signal. The percentage scale reads 1 per cent.

At first sight it appears that this kind of difficulty could be avoided by scaling each diagram in mV instead of percentages. This, however, would involve a new scale for every photograph, which would be impracticable.

On the other hand, if a percentage scale is used, three scales will serve for all purposes. In practice the percentage scale is determined as follows:—

(a) The cancellation circuit (7), (8) in Figs. 3 or 4

Fig. 8. Push-pull output stage with 100-c/s ripple in h.t. supply. (a) modulation with second and third harmonics. (b) driver stage balanced to remove second harmonic. (c) both second and third harmonics removed.

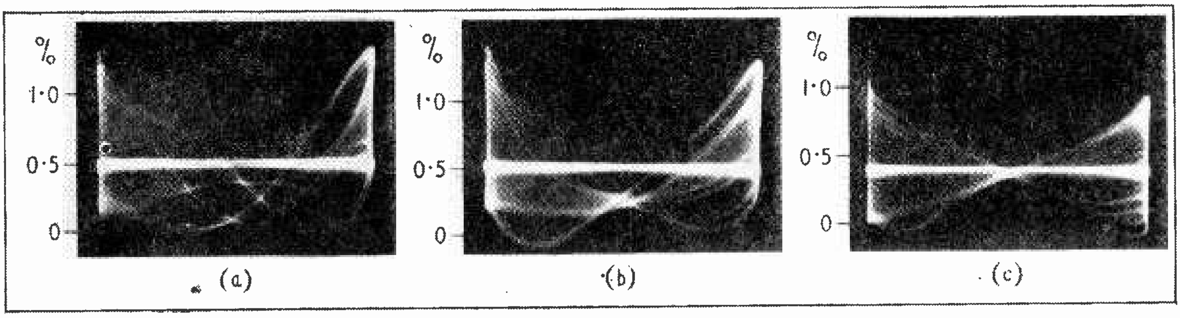
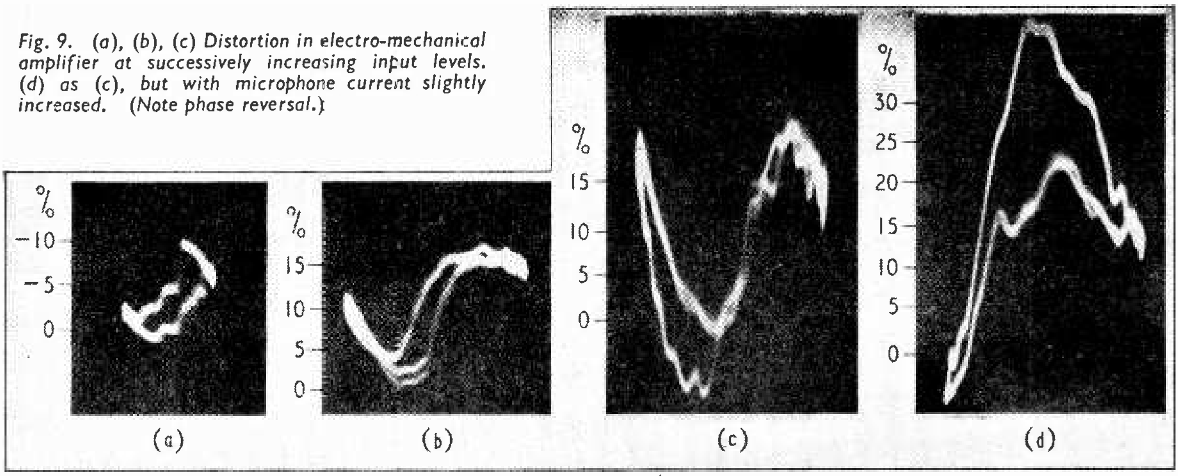


Fig. 9. (a), (b), (c) Distortion in electro-mechanical amplifier at successively increasing input levels. (d) as (c), but with microphone current slightly increased. (Note phase reversal.)



is interrupted, the X-signal removed, and the gain of the Y-amplifier adjusted to bring the resulting vertical line to a chosen height on the oscilloscope graticule. Let this height be D units.

(b) Having restored the cancellation circuit (7), (8) and the X-signal, the gain of the Y-amplifier is increased by a known amount (usually not more than 30 times) so as to make the details of the diagram clearly visible. Let the gain increase by N times.

(c) The percentage scale to be associated with this diagram must have an interval of DN/100 between the 1 per cent marks on the scale.

It is convenient to arrange that the Y-amplifier (A1) has several fixed steps of gain which are exactly known (say N=10, 30, 100), and to prepare in advance the corresponding percentage scales, which can be fixed to the face of the tube and photographed together with the diagram.

Simplifications. The somewhat elaborate networks of Figs. 3 and 4 can be simplified if no more than a general impression of the distortion is required. If changes of régime are considered unimportant, and only the larger distortion terms are of interest, the ganged attenuators and the "slave" oscillator chain (12) to (15) may be omitted.

Bridge-type circuits are a common feature of apparatus designed to measure total harmonic distortion, but although they provide an output which contains only the distortion terms, they cannot be used to generate a difference diagram, because the various distortion products are "dispersed," i.e., shifted in relative phase, by passing through the bridge network.

The essential components of a 2-terminal circuit are the phase-shifter and filter, (7) and (8). A 4-terminal circuit requires, in addition, a bandpass or possibly a low-pass filter at (2). The performance of these filters need not be superlative, for many commercial oscillators generate no more than 1 per cent or 2 per cent of second or third harmonics, which can be reduced to 0.1 or 0.2 per cent by 20db attenuation at (2). If a valve stage, which may generate distortion, is incorporated in (7), filter (8) should have a slightly better performance.

Photographing the Diagram. For the illustrations a Cossor oscilloscope, Type 1035, with a green tube, Type 89D, was used.

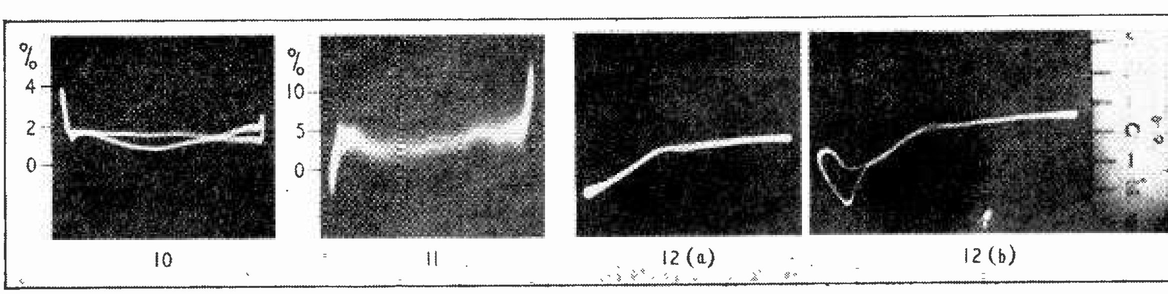
The photographs were obtained with a Leica II camera on Kodak 35mm orthochromatic film R55, with an exposure of $1\frac{1}{2}$sec at F/6.3. The brightness of the trace was adjusted for each exposure by the following procedure. The trace was dimmed until only just visible in its weakest part while being traversed to and fro by the X-shift control. The brightness control was then advanced by a fixed amount predetermined by trial exposures.

This procedure makes allowance for the influence of mains-voltage variations upon the brilliance of the spot, and also for the large variations in writing speed which are caused by changes of test frequency or size and degree of detail of the diagram.

The percentage scale will appear in the photograph if it has been attached to the face of the tube and is given local illumination.

Conclusion. It is not easy to bring out in a short survey the full merits of this technique; the informa-

Fig. 10. Oscillator running into grid current. Fig. 11. Disc recording grossly over-modulated. Fig. 12. Radio receiver with "delayed" a.v.c.; modulation (a) just below and (b) just above 100 per cent.



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tion given should, however, be sufficient to guide those who wish to explore its possibilities. The method has been in use in the Research Department of the B.B.C. in the course of the last 2-3 years, its development being part of a general investigation into distortion in a.f. systems.

The illustrations in this article are taken from a stock of several hundreds collected over this period. It should be noted that, in order to simplify discussion, the most elementary examples have been chosen, whereas in practice much more complex forms may occur. Fig. 9 has therefore been included to demonstrate the application of this new technique to a more complex problem.

For the investigation of distortion in recording systems the difference diagram has unique value, for unless the speed of the medium (disc or tape) is practically constant only the simplest of the conventional distortion measuring systems can be applied in such work. It is justifiable in such cases to attempt to deduce the harmonic content from a geometrical analysis of the diagram, should a numerical expression of the distortion be required. In general, the diagram serves its most useful purpose in bringing to light the nature of the distortion and its relationship to hum and circuit noise. The history of Fig. 8 is a striking example of this.

It is not unreasonable to suppose that there is a relationship between the shape of the diagram and the aural assessment of the resulting distortion. Indications of such relationship have been found, but cannot be discussed here.

APPENDIX

Operational Procedure. The circuits of Figs. 3 and 4 are used for 4-terminal and 2-terminal tests respectively. Their operation will be described for a 1,000 c/s test tone. For tests at any other frequency the filters must be changed. The figures marked against the filters refer to the attenuation peaks adjacent to the cut-off points.

In setting up the difference diagram of an amplifier the first operation is to put 20 db at (4) and zero at (6) (see Fig. 3). Add attenuation at (3) to bring the overall attenuation from (3)-(6) to about overload point. Vary (7) and slightly adjust (3) until the difference signal contains no fundamental tone. This will be shown by minimum vertical deflection of the oscilloscope trace. Turn up the gain of the X-amplifier of the oscilloscope to get a nearly horizontal line.

Now transfer attenuation from (4) to (6) thus driving (5) harder. The Y-deflection will grow and a loop will form. Adjust (11) until this loop closes to a line. When the input to (5) is small this line will resemble Fig. 2 if the output stage is a single valve. As the input increases a difference diagram like Fig. 5(a) will appear. The centre should be tangential to the X-axis of the tube. If not, adjust (3) very slightly to tilt the diagram correctly. If a loop appears as in Fig. 5(b) first adjust (7) and then (11) to remove it. The final curve is a representative difference diagram.

The phase shifter (7) should be designed to shift the phase without changing the amplitude of the 1,000-c/s signal, otherwise any adjustment will cause the diagram to tilt about its centre point and this has then to be corrected by readjusting (3).

The 2-terminal network is adjusted in much the same way, except that (3) is adjusted initially to equal the loss in (7) and (8).

In some amplifiers a change of operating regime occurs as the drive increases. This is shown up by a 4-terminal test but not by a 2-terminal test. The gain at 1,000 c/s alters and the diagram tilts about its centre point. The change in gain can be measured by introducing a slight compensating loss in the (7) (8) chain to restore the diagram to its original position.

The most difficult adjustment is the setting of phase shifter (11). If there are "overload spikes" as in Figs. 10 and 11 there is no difficulty, for it is clear that these must be located at the extremities of the X-axis. Sometimes artificial "spikes" have to be introduced (by a biased-off diode or rectifier) before the correct setting of (11) can be found.

When, as in Figs. 9(c) and (d), the "go" and "return" traces are different and have to be displayed separately for examination, the diagram is opened into a loop by a slight readjustment of (7).

If oscillator (15) uses a 2-valve zero-phase-shift RC circuit, it can be locked by injecting the "spike" from (14) into the common anode lead. No frequency calibration is needed, since the harmonic number can be read from the trace which appears when the output of (15) is made large enough. The magnitude of the spike signal must be adjustable so that it locks the oscillator without introducing visible distortion.

Cancellation of the unwanted distortion term can be observed on headphones connected temporarily to the output of the Y-amplifier of the oscilloscope. Phase-shifter (12) can be of a simple type in which the output voltage is not strictly independent of the phase adjustment, for the size of the locking "spike" will not seriously affect the output of the oscillator (15).

EARL'S COURT

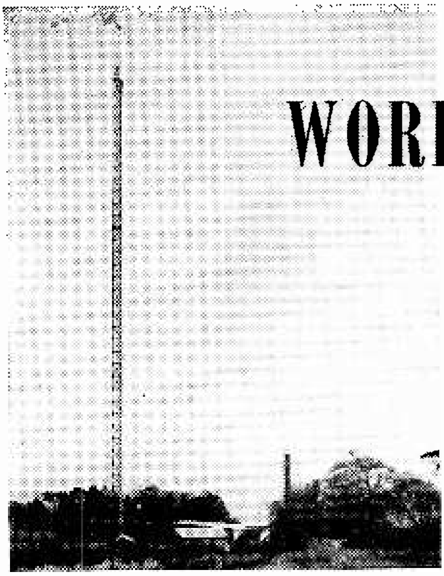
Preliminary List of Exhibitors

AS a result of the recent ballot for space at the 20th National Radio Show to be held at Earl's Court from September 1st to the 12th, the Radio Industry Council has issued a preliminary list of exhibitors. In addition to the 80 manufacturers, traders and journals, etc., listed below, four banks, British Railways, the Electrical Trades Union, and the Association of Radio Battery Manufacturers have also taken space.

Aerialite, Ambassador, Antiference, Argosy, Automatic Coil Winder.
B.B.C., Baird, Balcombe, Belling & Lee, Bernards, Boosey & Hawkes, Bowmaker, Brown Brothers, Bulgin, Bush.
C.W.S., Cole, Collaro, Cosmocord, Cossor.
Decca, Dubilier, Dynatron.
Econasign, Edison Swan, English Electric, Ever Ready, *Electrical & Radio Trading*.
Ferguson, Ferranti.
G.E.C., Garrard, Goodmans, Gramophone Co.
Hobday, Hunt.
Invicta.
J.B. Manufacturing.
Keith Prowse, Kerry's, Kolster-Brandes.
Linguaphone, Lugton.
McMichael, Marconiphone, Masteradio, Mullard, Multicore, Murphy.
Peto Scott, Philco, Philips, Pilot, Plessey, Portogram, *Practical Wireless*, Pye.
R.G.D., Regentone, Reproducers, Roberts, Rola-Celestion.
S.T.C., Simon Sound Service, Sobell, Stella.
T.C.C., Taylor Electrical Instruments, Telerection, Thompson, Diamond & Butcher, Truvox.
Ultra.
Valradio, Vidor.
Westinghouse, Whiteley, *Wireless World* and *Wireless Engineer*, *Wireless Trader*, Wolsey, Wright & Weaire.

Plans for the exhibition, which will be open to the public from September 2nd, include considerable space for displays of radio and electronic equipment to be provided by the Services and manufacturers. It is also planned to have an educational and training exhibit on the lines of that introduced last year. Technical training colleges will be represented by Norwood T.C. and the Borough Polytechnic and industrial training establishments by E.M.I. Institutes and Marconi College. The B.B.C. Engineering Training Department will be participating and the universities will also be represented.

Many of the exhibitors will be equipping demonstration rooms and there will be the usual Television Avenue in which manufacturers have the opportunity of demonstrating their receivers.



WORLD OF WIRELESS

Mobile Television Transmitters ✦ Standard Frequencies ✦ New Amateur Band

New TV Stations

THE temporary low-power mobile stations at Glencairn (Belfast) and Pontop Pike (Newcastle) were brought into regular service by the B.B.C. on May 1st. Pontop Pike is linked with the main radio network, but Glencairn relies on its direct reception of the Kirk o' Shotts transmitter for rebroadcasting. Initially, the Newcastle station used a temporary aerial, but the main radiator, which will eventually be employed by the permanent medium-power transmitter, is now in use.

Both stations use horizontal polarization and their sound and vision carriers are slightly offset from those of the main high-power transmitters using the same channel to reduce interference. Glencairn, shown with its Marconi aerial in the above photograph, operates in Channel 1 (41.5 and 45 Mc/s), and Pontop Pike in Channel 5 (63.25 and 66.75 Mc/s).

The low-power booster station near Brighton started a regular service on May 9th. It uses vertical polarization, operates in Channel 3 (53.25 and 56.75 Mc/s) and relies on its direct reception of Alexandra Palace for rebroadcasting. As in the case of the other two low-power stations, Brighton's carriers are slightly offset.

MSF Schedules

STANDARD FREQUENCY transmissions from the Rugby station MSF are now being radiated continuously for 24 hours a day. In accordance with the Atlantic City Convention (1947), the carrier frequencies will be 2.5, 5, 10, 15 and 20 Mc/s, but only three of these will be used simultaneously. Initially the transmissions are being radiated on 2.5, 5 and 10 Mc/s with a power of 0.5 kW.

These frequencies are not the most suitable for reception within the United Kingdom and it has, therefore, been decided to continue the transmissions on 60 kc/s for a short period each day. A power of 10 kW will be used for this transmission which will be radiated from 1429 to 1530 G.M.T.

The carriers will be modulated in accordance with the following cycle (repeated each quarter of an hour): 0-5 mins, 1,000 c/s tone; 5-10 mins, 1 c/s pulses (59th pulse in each minute being omitted); 10-14 mins, unmodulated; and 14-15 mins, speech announcement. The carrier and modulating frequencies are derived from the same 100-kc/s standard and are maintained to within ± two parts in 10^8 of their nominal values.

Results of N.P.L. measurements of these transmissions are given each month in our sister journal *Wireless Engineer.*

Coronation Radio

BIGGEST-EVER radio hook-up has been planned by the B.B.C. for the Coronation Day broadcasts. In addition to the television arrangements (which include the relay to Europe detailed on pages 274 and 275) and those for home listeners, the entire transmitting equipment of the External Services of the Corporation will be employed. This includes thirty-six high-power and two medium-power short-wave transmitters in this country, six in Malaya, two in Canada and two in Ceylon as well as m.w. transmitters in this country, Germany and Austria.

The B.B.C. has also been asked to provide land lines for a large number of overseas broadcasting authorities, while many other countries are retransmitting the received programme. It is estimated that in all some 1,000 stations throughout the world will be broadcasting some part of the day's proceedings. Eighty-four microphone positions for commentaries in 44 foreign languages have been provided by the B.B.C.

Amateur 2-Mc/s Band

SINCE MAY 1ST amateurs in the U.K. have not been permitted to use the band 1715-1800 kc/s, but instead have been granted the 200-kc/s band above 1800 kc/s. This change was necessitated by the enforcement of part of the Atlantic City allocation table and the Geneva frequency plan covering that band.

It will be recalled that in the Atlantic City Radio Regulations there was no 2-Mc/s allocation in Region I (Europe and Africa) for amateurs. A footnote to the frequency allocation table, however, reads "In the band 1715-2000 kc/s, Austria, Ireland, the Netherlands, Northern Rhodesia, Southern Rhodesia, Switzerland, the Union of South Africa and the United Kingdom may assign up to 200 kc/s for the amateur service provided that the mean power of any amateur station does not exceed 10 watts and that no harmful interference is caused to the authorized services of other countries."

The Radio Society of Great Britain in giving details of the change lists the maritime stations (see p. 214 of our last issue) in the band which are likely to be particularly vulnerable to interference.

"Trader Year Book"

THE "Wireless and Electrical Trader Year Book, 1953," to give it its full title, is a veritable mine of information—technical, legal and general—for the radio and electrical trader. This 24th edition includes thumbnail specifications of current broadcast and television receivers, i.f. values of broadcast receivers marketed between 1947 and 1951, valve base connections and mains voltages in the principal towns in Great Britain. It also includes in its 264 pages directories of trade organizations, manufacturers, wholesalers and proprietary names. It is published by the Trader Publishing Co., Dorset House, Stamford Street, London, S.E.1, price 10s 6d.

Modern Navigational Aids

AN EXHIBITION "Navigation Today" has been arranged from now until September at the Science Museum, South Kensington, to show the basic principles of navigation and the changes which have taken place in navigational methods under the impact of high-speed flying and the developments of radio and radar.

There are demonstrations of such radio aids as Consol, Gee, Decca Navigator, v.h.f. omni-range, ground controlled approach and, of course, radar. The latter includes an interesting supersonic simulator by Kelvin and Hughes of the Thames approaches in which model craft in motion on water are reproduced on a standard p.p.i. display.

Firms contributing to the exhibition include S. G. Brown, Cossor, Decca, G.E.C., Kelvin and Hughes, Kolster-Brandes, Marconi, Siemens, Sperry and Ultra.

PERSONALITIES

Wing Commander R. Stanford-Tuck, D.S.O., D.F.C., who joined Marconi's W.T. Co. in 1949, and earlier this year was appointed sales manager of the Aeronautical Division, has been released by the company to join the Aircraft Division of the English Electric Co. Marconi's is a member of the group of which English Electric is the parent company.

H. R. L. Lamont, Ph.D., M.A., B.Sc., A.M.I.E.E., has recently joined the scientific staff of the European Technical Representative of the Radio Corporation of America whose office is in London. Dr. Lamont, who is well known for his book on waveguides, will be principally concerned with technical liaison. Until his present appointment he was senior lecturer in electronics at the Royal Technical College, Glasgow, and was formerly at the G.E.C. Research Laboratories, Wembley.

C. L. G. Fairfield, M.A., M.I.E.E., A.M.I.Mech.E., who has joined the Telegraph Construction and Maintenance Co., Ltd., as manager of the overseas division, had been with Mullard, Ltd., since 1947, latterly as manager of the valve division. He has been a director of Mullard Equipment, Ltd., for the past two years, and was a Mullard representative on the board of Telcon Telecommunications, Ltd.

Wilfred Sampson, B.A., A.M.I.E.E., has been appointed commercial manager of Telcon Telecommunications, Ltd. (owned jointly by Mullard, Ltd., and the Telegraph Construction and Maintenance Co., Ltd.). A graduate of Queen's, Cambridge, Mr. Sampson joined the transmission systems division of Standard Telephones and Cables, Ltd., in 1929, where he gained wide experience in the field of telecommunications both in this country and abroad, particularly in South Africa.

J. Foster Veevers, M.I.E.E., has resigned his recent appointment as general manager of the Swindon factory of the Plessey Company to become managing director of Peto Scott Electrical Instruments, Ltd. Before joining Plessey's he was for many years manager of the Stockport factory of Salford Electrical Instruments, Ltd.

Until his recent appointment as senior liaison engineer of the Components Division of the Plessey Co., **E. Morgan,** B.Sc., A.M.I.E.E., had been in the Engineering Division of the B.B.C. since 1950. He had held the positions of superintendent engineer (transmitters) and assistant head of the Valve Section. Before joining the Corporation he was a member of the technical sales staff in the Osram Valve Department of the General Electric Co.

OUR AUTHORS

Ralph W. Hallows, who has been a frequent contributor to *Wireless World* for the past 21 years, writes in this issue on the efficiency of the dry cell and suggests ways in which its design and construction might be improved. He has been European Consultant to the Burgess Battery Co. Inc. since 1925. During the war he was a major in the Royal Artillery and became chief instructor (radar) at the 6th A.A. Group School. Major Hallows, who was an open exhibitioner at Magdalene College and an honours M.A. (Cantab.), is author of a number of books including "Radar Simply Explained" which has been translated into six European languages.

E. R. Wigan, who writes in this issue on the diagnosis of distortion, spent some 14 years in industry (graduating from d.c. and 50 c/s on the test beds of the G.E.C., Witton, in 1924 to audio and carrier frequencies in the laboratories of Siemens Bros., Woolwich, before joining the Signals Research and Development Establishment, Ministry of Supply, in 1938. At S.R.D.E. he was primarily concerned with the design of acoustic and a.f. field equipment and the associated test gear. Since 1949 Mr. Wigan has been in the B.B.C. Research Department, Kingswood Warren, Surrey, dealing with problems associated with distortion.

Eric Griffiths, contributor of the article on the design and construction of portable equipment in our last issue, is in the Lines Department of the B.B.C. Since joining the Corporation in 1941 he has worked at both transmitter and studio centres, and was for some time an instructor in the Engineering Training Department. Before joining the B.B.C. he was in the Research Laboratory of Callender's Cables (1936-39) and with the Ministry of Supply (1939-41).

OBITUARY

It is with regret that we record the sudden death of **Simon Orde,** manager of the B.B.C. Engineering Information Department, on April 23rd at the age of 59. Mr. Orde joined the Corporation in 1942 as a censor and in 1943 transferred to the Engineering Division.

We record with regret that **Charles Walter Eve,** a former director of Standard Telephones and Cables, Ltd., and a director of Kolster-Brandes, Ltd., died on April 19th aged 66. He joined S.T.C. in 1906 and retired in 1947. Mr. Eve was closely associated with the formation of the Radio Industry Council, the Radio Communication and Electronic Engineering Association and the Telecommunication Engineering and Manufacturing Association, and was at one time vice-chairman of the British Radio Valve Manufacturers' Association.

IN BRIEF

Broadcast Receiving Licences totalled 12,892,231, including 2,142,452 for television sets and 183,996 for car radio at the end of March. The month's increase in television licences totalled 69,472.

Stand-by Equipment has now been installed at the Sutton Coldfield television station and the switching arrangements permit it to be used with either the main or stand-by aerials. The powers are vision 5 kW, sound 2 kW. The last of the main stations to be equipped with stand-by gear is Alexandra Palace, where similar Marconi transmitters are now being installed.

Radio Exports.—Of the £2.2M worth of radio equipment exported in March, £855,084 was for capital goods—transmitting gear, etc. According to Customs and Excise figures, components and test gear accounted for £454,580, domestic receivers £442,072, sound reproducing equipment £253,128, and valves £216,531.

Plastics Exhibition.—Among the 90 exhibitors at the British Plastics Exhibition, which will be held at Olympia from June 8th to 18th (10 a.m. to 6 p.m. daily) are the following radio and electronic manufacturers:—E. K. Cole, G.E.C., Radio Heaters, Redifon and T.C.M. Admission to the exhibition costs 2s 6d, but free tickets for the convention which runs concurrently with the show are available from *British Plastics* (the organizers), Dorset House, Stamford Street, London, S.E.1.

Instruments.—The second British Instrument Industries Exhibition opens in the National Hall at Olympia on June 30th for 12 days. The Scientific Instrument Manufacturers' Association is among the five supporting organizations. The exhibition will be open daily, except Sunday, from 10 to 6.30.

Canadian Trade Fair.—Eight British publishers are combining to present a display of 55 technical, trade and specialized journals at the sixth Canadian International Trade Fair, to be held in Toronto from June 1st to 12th. Our own publishers will be exhibiting 24 journals including *Wireless World* and *Wireless Engineer.* Among the British companies participating in the fair is the G.E.C., who will be exhibiting the BRT400E communication receiver and v.h.f. gear.

Communications in the widest sense will be featured at the German Communication and Transport Exhibition which opens in the 670,000-sq yd Munich Exhibition Park on June 20th. The exhibition, which will remain open until October 11th, will include sections devoted to broadcasting, radio-telegraphy and telephony and navigation.

German Radio Show, which was to have been held last August and has twice been postponed, will open in Dusseldorf on August 29th for nine days.

A.P.A.E. Officers.—At the annual general meeting of the Association of Public Address Engineers, L. W. Murkham was re-elected president. The vice-presidents are A. V. Sharp, J. F. Doust, C. Clarabut (who is also chairman of the Council), A. H. Middleton and Alex J. Walker, who is also honorary general secretary. The Council consists of G. F. Baker, A. B. Hulme, W. O. Mannerings, A. E. Buchan, F. Hedges, A. E. Ward, R. Jackson and S. W. Lewis (trade members), and R. E. Owen, J. F. Doust, F. Poperwell, S. Norley, A. V. Sharp, S. Kelly, C. T. Wright and P. Whiteley (manufacturing members).

"Solid-State Electronics," which is at the foundation of such practical applications as germanium diodes, transitors and other semi-conducting devices, will be dealt with by Dr. Karl K. Darrow of Bell Telephone Laboratories, in a series of four lectures at King's College, Strand, London, W.C.2, at 5.30 on June 22nd, 23rd, 25th and 26th. Although the lectures are addressed to students of London University, admission is free to others interested in the subject.

Transistor circuitry and applications will be dealt with by G. C. Sziklai of the R.C.A. Research Laboratories, Princeton, U.S.A., at a meeting at the Royal Society of Arts, John Adam Street, London, W.C.2, at 5.30 on July 1st. Dr. R. L. Smith-Rose will be in the chair. Tickets are available from the R.C.A. European Technical Representative, The Tower, Brook Green Road, London, W.6.

Electro-Acoustics.—A series of 10 lectures covering the nature, generation, propagation, measurement, recording and reproduction of sound has been planned by the Department of Radio and Musical Instrument Technology at the Northern Polytechnic, Holloway, London, N.7. The lectures by E. H. Jones, B.Sc., A.M.Brit.I.R.E., will be given on Tuesdays and Thursdays, commencing on June 4th. The fee is two guineas.

Fringe-area Reception.—A series of papers on this subject will be given at the summer meeting of the Television Society, which will be held at Bedford on June 27th.

Photographing TV Pictures.—Readers interested in the photographing of television pictures from the cathode-ray tube may like to know that in the Coronation number of *Amateur Photographer* (May 27th) there is an article dealing with the subject.

"Designing a Tape Recorder."—In the complete circuit diagram (Fig. 7, p.231, May issue) the cathode resistor R_{26} of V_6 should be 470 ohms and in Fig. 4 (p. 165, April issue) C_{27} should be 0.5μF.

SIR NOEL ASHBRIDGE. The Radio Industry Council is to present him with this portrait by Frank O. Salisbury. Sir Noel was recently elected an honorary member of the Brit.I.R.E. "in recognition of his services to the radio engineering profession of Great Britain and as a tribute to his outstanding work in developing the technical services of the B.B.C."

LITERATURE

Engineering Education.—A booklet setting out the full-time and part-time courses in technical education available at colleges and institutes in London and the Home Counties has been issued by the Regional Advisory Council for Higher Technological Education. It includes a list of courses in radio and television servicing, in telecommunications for the C. & G. certificates and in electrical engineering for the Higher National certificate. It is available from Tavistock House South, Tavistock Square, London, W.C.1, price 1s.

Metric Edition of the British Standard for enamelled round copper wire (oleo-resinous enamel) has recently been published as B.S.1961:1953. It differs from the 1951 edition of B.S.156 only in that all quantities are expressed in metric units. Copies may be obtained from the British Standards Institution, 24, Victoria Street, London, S.W.1, price 4s.

Technical Papers issued by all departments of the Department of Scientific and Industrial Research, including the National Physical Laboratory and the Radio Research Station, are listed in the 31-page catalogue "Government Publications, Sectional List No. 3 D.S.I.R.", revised to March 1st. It is obtainable free from H.M. Stationery Office, York House, Kingsway, London, W.C.2.

Scientific Literature published by and for the Institute of Physics is listed in a catalogue which is obtainable gratis from the Institute, 47, Belgrave Square, London, S.W.1. A summary is given of some 30 books, monographs and pamphlets including "Physics as a Career" by N. Clarke, which deals with the fields of work open to physicists and the training necessary.

BUSINESS NOTES

Emitron Television, Ltd., are to supply two flying-spot film channels for the new television station being built by the Italian broadcasting organization (Radio Audizioni Italiano) at Turin. They will operate on 625 lines and are fitted with magnetic heads for reproduction of sound tape recordings. Either married or single picture and sound films can be used.

Mullard is to transfer the manufacture of cathode-ray tubes from its factory at Mitcham, London, to a new Government-financed factory of approximately 250,000 sq ft to be built in the North-East Lancashire Development Area. The vacated space at the Mitcham factory will be utilized for the production of other electronic devices.

B.I. Callender's Cables, Ltd., have formed a new company in Australia to co-ordinate the activities of agents in the Commonwealth and to establish a technical service organization. The registered office of British Insulated Callender's Cables (Australia), Pty., Ltd., is 84/88, William Street, Melbourne, C.I., Victoria, Australia. B.I.C.C. has also formed a Canadian company. It has acquired the business of Phillips Electrical Works, Ltd., of Montreal and Ontario, which will now be known as Phillips Electrical Company (1953), Ltd.

Modern Acoustics, Ltd., of Manor Way, Boreham Wood, Herts, (Tel.: Elstree 3636), has been formed to manufacture "Lectrona" loudspeakers which were previously produced and marketed by Acoustic Products, Ltd. E. L. Edwards, late of Edstone, Ltd., is managing director of the new company.

Mattis Industries, Ltd., of 4, John Adam Street, London, W.C.2, (Tel.: Trafalgar 5502), inform us that they have been appointed sales representatives for London and the Home Counties for the "Milaflex" range of insulating silks, tapes and cloths manufactured by Miller & Ferguson, Ltd., of Glasgow.

Decca's Glasgow office, which deals with both radar and navigation business, is now at 67, Blythswood Street, Glasgow, C.2, (Tel.: City 6457/8). The manager is R. E. G. Simmons.

London Docks servicing depot of Rees Mace Marine, Ltd., is now at Yabsley Street, Poplar, E.14, (Tel.: East 4216). It is under the management of R. Aveyard.

Exporting Computers.—The second electronic digital computer to be produced by Ferranti, Ltd., for export has been ordered by the Royal Dutch/Shell Group for installation in their research establishment in Amsterdam.

B.T.H. has received an order from the European Headquarters Command of the U.S. Army for $4M worth of mobile fire-control radar equipment for supply to N.A.T.O. countries.

Marconi Marine radio and navigational equipment is being supplied by Marconi's associates Deutsche Betriebsgesellschaft für Drahtlose Telegrafie M.B.H., for four motor vessels being built at Rendsburg on the Kiel Canal.

TRANSISTOR AMPLIFIER

PROBABLY the first piece of commercial apparatus on the British market to make use of a transistor is a small pocket amplifier for boosting the outputs of hearing-aids.

Designed by Multitone, it is intended for hearing-aid users who get adequate output from close-range sounds but not enough from sounds at a distance. The G.E.C. Type GET1 point transistor used gives a power gain of about 15 db, and it has to be used with a high-impedance earpiece which is supplied with the instrument. The cylindrical housing has a plug at one end to fit into a standard hearing-aid battery ($22\frac{1}{2}$ V or 15 V), and two sockets at the other for the input and output plugs and cords. Multitone have also produced a hearing-aid with a transistor output stage, the main object being to reduce l.t. consumption.

No More "Reliable" Valves

VALVE manufacturers in this country deplore the use of the term "reliable valves" because it implies that all other valves are not reliable. Their trade association, the B.V.A., now announces that it intends to describe these valves as "Special Quality" in future. A "Special Quality" valve is defined as "a valve which has certain design and manufacturing features making it suitable for use under conditions different from or in excess of those experienced in normal radio or television receivers and when operated under stated or agreed electrical or mechanical conditions it has an acceptable statistically determined expectation of life."

This definition covers several classes of valves, for example, those which will withstand severe mechanical shock but do not necessarily have long lives; those which have particularly long lives or high electrical stability but not so much ability to withstand shock; and those giving normal lives under moderate conditions of shock and vibration. Thus the term "Special Quality" has quite a wide meaning, and does not really distinguish the particular class of valves hitherto known as "reliable" from valves with other special qualities such as long life or stability.

Books Received

Television Picture Faults. By John Cura and Leonard Stanley. Contains 150 photographs of television pictures illustrating various faults together with explanations of their cause. These explanations are printed in contrasting types for readers with and without technical knowledge. The faults mainly comprise those resulting from incorrect adjustment of the controls, but various forms of interference are also illustrated. Pp. 68. Television Times, Ltd., 39a, Bartholomew Close, London, E.C.1. Price 3s 6d.

Radio Engineering (Second Edition). By E. K. Sandeman, Ph.D., A.C.G.I., M.I.E.E. Method of approach is fundamental and general, though specifically related to practical ends. The book grew from an instruction manual written primarily for maintenance engineers at B.B.C. stations. Pp. 613+xxi; Figs. 204. Chapman and Hall, 37, Essex St., London, W.C.2. Price 55s.

Télévision Dépannage. By A. V. J. Martin. A practical book on the installation, adjustment, fault-tracing and repair of television receivers. Pp. 176; Figs. 197. Société des Editions Radio, 9, Rue Jacob, Paris, 6. Price 600 francs.

Modulators and Frequency-changers. By D. G. Tucker, D.Sc. An analytical and largely mathematical approach to the subject as applicable to amplitude-modulated radio and line systems. The book is intended for design and maintenance engineers. Pp. 218+xiv; Figs. 115. Macdonald and Company, 16, Maddox St., London, W.1. Price 28s.

The Living Brain. By W. Grey Walter, M.A., Sc.D. (Cantab). Basically a book about research into the mechanics of the brain by means of electro-encephalography (and intended for general reading), but contains technical information on EEG apparatus developed by the author with appendices describing his electronic analogues of physiological mechanisms. Pp. 216+xii; Figs. 23. Gerald Duckworth & Co., 3, Henrietta Street, Covent Garden, London, W.C.2. Price 15s.

"Radio Designer's Handbook"

MANY thousands of copies of earlier editions of "Radio Designer's Handbook" have been sold throughout the world. The fourth edition of this popular work, just issued by our Publishers (price 42s; by post 43s 6d) is more than four times as large as its predecessors. The book deals in detail with basic principles and the practical design of all types of modern radio receivers, audio amplifiers and record-reproducing equipment. It is the work of 10 authors and 23 collaborating engineers, under the editorship of F. Langford-Smith.

CLUB NEWS

Birmingham.—The June programme of the Slade Radio Society includes two direction-finding contests. On the 12th there is to be an evening contest and on the 13th-14th the second event for the Harcourt Trophy. There will be a technical discussion evening on the 26th at 7.45 at Church House, Erdington. Sec.: C. N. Smart, 110, Woolmore Road, Erdington, Birmingham, 23.

Coventry Amateur Radio Society's "night on the air" has been suspended for the summer months, but meetings continue to be held on alternate Mondays at the Y.W.C.A., Queens Road, at 7.30. On June 8th G2BVW will talk about 70-centimetre operation. There will be a v.h.f. field-day on Sunday, June 21st. Sec.: K. G. Lines (G3FOH), 142, Shorncliffe Road, Coventry.

Hastings and District Amateur Radio Club, of which L. H. Thomas, M.B.E. (G6QB), assistant editor of *Short Wave Magazine*, is president, is participating in the Hobbies Exhibition to be held in the town during Carnival Week, July 4th-11th. Membership of the club, which during the summer meets only once a month, is now over 30. Sec.: W. E. Thompson, 8, Coventry Road, St. Leonards-on-Sea.

Manchester.—The South Manchester Radio Club (G3FVA) meets on alternate Fridays at 7.30 at Ladybarn House, Mauldeth Road, Fallowfield, Manchester, 14, and is planning a course of instruction for the Radio Amateur Examination. Sec.: M. Barnsley (G3HZM), 17, Cross Street, Bradford, Manchester, 11.

Reading.—Meetings of the Reading Radio Society, of which W. A. Smallcombe, B.Sc., was recently elected president, are held on the second and last Saturdays of each month at 7.0 at the Abbey Gateway, Reading. The programme for the coming session includes lectures, debates and demonstrations. Sec.: L. A. Hensford (G2BHS), 30, Boston Avenue, Reading.

Southend.—At the meeting of the Southend and District Radio Society on June 12th S. W. F. Asquith, A.M.I.E.E., will talk on frequency measurement. The winners of the recently awarded Pocock and Hudson Cups for home-built gear—J. Wallace and D. Whitworth, respectively—will demonstrate their equipment at the meeting on June 26th. Meetings are held on alternate Fridays at 7.30 in the Queen's Road Annexe of the Municipal College, Victoria Circus. Temp. Sec.: J. H. Barrance, M.B.E. (G3BUJ), 49, Swanage Road, Southend-on-Sea.

LETTERS TO THE EDITOR

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

Two-band Television Reception

WHEN alternative television programmes are provided, whether by the B.B.C. or by sponsoring or by both, it is plain that the new stations must operate on frequencies higher than the present 40-70 Mc/s band. New television sets will be designed to cover the new band as well as the old and must obviously include some station-selection mechanism.

The problems of design are technically straightforward ones, but what about the several million existing sets? Has anyone yet thought seriously about the problem of making them suitable? The usual glib answer is that cheap, mass-produced converters will be produced which will enable the frequency of the new station to be changed to that for which the receiver is designed.

That is a satisfactory solution provided that the converter does what it is supposed to do, but will it? It seems to me that there are a great many technical snags.

It so happens that most existing television sets are not readily tunable from one channel to another and some cannot be changed at all without a major operation. In order that normal reception of the station in the 40-70 Mc/s band may be retained, therefore, the receiver must be left tuned to this station and the converter must operate to change the frequency of a signal in the higher band to this lower frequency. There is then a possibility of interference due to the direct pick-up of signals from the 40-70 Mc/s station by the early circuits of the receiver. For the avoidance of interference a disparity of some 50 db between the two signals is required. In some areas and with some receivers this may be easily obtainable, but when the receiver is used near a 40-70 Mc/s station and remote from one of the new ones, the interference may well be intolerable. This is especially likely to be so with some of the earlier receivers which were not very well screened.

The solution would seem to lie in having the television set permanently tuned to a channel other than the local one—say to Sutton Coldfield in the London area—and to include in the converter provision for changing the frequency of the local 40-70 Mc/s station to this chosen channel. The converter then becomes necessary for all reception. This will increase its cost and the changing of the tuning of the set itself may be an expensive matter with some sets, although negligible with others.

In addition to this, where the television set is a superheterodyne, as most now are, the set plus converter will be a double superheterodyne having two oscillators. The almost limitless possibilities of self-generated interference by beats between their harmonics are well known and it seems likely that satisfactory operation would be largely a matter of chance and would depend on the precise frequencies of the signal, the input of the set (1st i.f.), the i.f. of the set (2nd i.f.) and upon whether the oscillator of the television receiver is above or below the signal. The converter oscillator will have to be always below the signal to prevent inversion of the sound and vision channels.

The development and rapid growth of competitive television services will depend very much on the finding of satisfactory solutions to all these problems.

London, N.14. W. T. COCKING.

Broadcast Transmitter Distortion

THE letters of Ian Leslie in your April issue and A. Yates in your May issue both deal with the overall performance of the broadcasting chain, and a few notes on B.B.C. practice may be of value.

There is, of course, no such thing as completely distortionless transmission, and the problem facing any authority engaged in broadcasting is to what extent shall distortion be permitted. If no restriction of volume range is used between microphone and transmitter, and the modulation is adjusted to such a level that 100 per cent modulation is never reached, then distortion may be very slight, but the average level of modulation will be extremely low, and listeners will rightly complain of excessive background noise due to interference and receiver noise in the quiet passages. For these reasons it is the practice in this and every other country to adjust levels manually so as to bring up the quiet passages and to keep down somewhat the level of the loud passages. This is done at the originating point in the programme chain. Sharp transients will, however, always occur, probably of such short duration as to be unobserved at the manual control position, and in any case so short as to make it impossible to take any human steps to limit their amplitude. In order to deal with this situation automatic means of amplitude limitation are incorporated at the transmitter input. These ensure that such transients cannot cause the transmitter to be modulated more than 100 per cent. Admittedly while so doing a certain amount of distortion is necessarily introduced by a very short period of time, but this distortion is very much less than that which would be heard by listeners if the transmitter were modulated more than 100 per cent. In that case the carrier amplitude would be reduced to zero for short periods of time and a very noticeable distortion radiated. Also, of course, heavy over-modulation can be very dangerous for the transmitting equipment.

The extent to which the average programme level is raised, and the extent to which limitation is used, is, of course, very much dependent on judgment of the degree to which distortion is acceptable, and on a balance being made between the amount of such distortion and the improvement in signal-to-noise ratio for the general listener. This improvement in signal-to-noise ratio is particularly important at times like the present, when on certain wavelengths there is appreciable interference from continental broadcasting stations.

The B.B.C. has arrived at its present standards after very careful listening tests, and believes that in the existing circumstances these represent the best compromise between distortion and interference.

Within the restricted band of frequencies available for medium-wave broadcasting there seems to be no prospect whatsoever of any appreciable reduction in interference from stations in other parts of Europe, and in fact a probability that this may increase. To increase the power of the medium-wave stations is not permitted by the Copenhagen Plan, and in any case to increase by an adequate amount would in most cases be impracticable. The hope for future improvements in transmitting conditions lies therefore in the development of a v.h.f. broadcasting service. The B.B.C. has published the results of its experimental transmissions from Wrotham, and the development of a regular service is now under consideration by the Advisory Committee set up by the Postmaster General under the terms of the Government White Paper on Broadcasting.

Mr. Yates is in error in stating that we rarely give live transmissions. Of the programmes radiated after 6 p.m. in the week ending May 2nd, recorded programmes represented 25 per cent of the Home Service, 40 per cent of the Light Programme, and 62 per cent of the Third Programme. In any case, for the vast majority of recorded programmes the quality of reproduction is indistinguishable from that of a live programme. The continued introduction of new recording and reproducing equipment should in time eliminate all unsatisfactory recorded items.

The quality of transmissions over the land lines from the studio to the various transmitters is subject to continual careful check. Only very occasionally does the quality of transmission deteriorate, and in such cases it is rectified at the earliest possible moment.

Consideration has been given to the use of the sound channels of the television service for the transmission of a sound programme, but the continued development of the television service and the fact that the equipment is in use for television purposes at times when the greater part of the public would wish to listen precludes such use.

The conclusion drawn by Mr. Yates that the general average of performance has deteriorated in the last twenty years is, I think, not justified, as the improvements in the design of the equipment in the transmitting chain over the last twenty years have been very appreciable, while every care in the operation and maintenance of the equipment continues to be taken.

London, W.1. F. C. McLEAN,
Deputy Chief Engineer, B.B.C.

I WAS interested to see A. Yates' letter, supporting my plea for better B.B.C. transmission quality, in your May issue.

As regards the use of recordings, I wrote to the Director of the Third Programme last autumn deploring the trend towards the development of a "transcribed service" and pointing out that, apart from questions of optimum signal quality, those shortcomings which identify the medium used—rumble, regular clicks due to a scratch, the change in quality as between the end of one disc and the start of the next—produce a mental image of the revolving turntable and destroy the illusion of reality, that psychological factor so important in a live service.

In reply I was informed that the extensive use of recordings is both necessary and expedient in a comprehensive service. Further, I was invited to Broadcasting House and shown that on direct playback (pickup tracking the groove freshly made by the cutter, with monitor switched instantaneously to input line or replay amplifier at will) the reproduced signal is almost indistinguishable from the input signal and total background noise imperceptible. I was told, and it was evident, that deterioration in the signal finally radiated is due to deterioration in the equipment of the playback channels, and in the recorded discs, due to careless handling by staff other than that of the recording department. There can be no excuse for this.

That improvement is possible in landline quality is indicated by the fact that excellent quality is in fact obtained from landline relays—sometimes. It is doubtful whether the use of television transmitters for sound services would serve any useful purpose in view of the fact that they would only be available at odd, "off-peak" hours. As regards the development of a comprehensive f.m. service, clearly the B.B.C.'s hands are tied by the financial powers-that-be.

Regarding automatic volume compression, the B.B.C.'s Parthian shot was a suggestion that I should see the matter in perspective; that "there is nothing more annoying than a strong carrier with low average modulation." I strongly disagree. Average level means nothing; minimum level matters but can be maintained by manual monitoring. Various measures can be undertaken by the listener to improve signal pick-up and/or mitigate interference of all types, but nothing can be done to correct a signal that contains non-linearity distortion. Many aspects of the interference problem are out of the B.B.C.'s control, but radiated signal quality is entirely their responsibility; in this at least let them set their house in order.

London, N.10. IAN LESLIE.

Flywheel Sync

THE observation made in the opening paragraph of K. G. Beauchamp's letter in the April issue on the flywheel synchronizing circuit, described by B. T. Gilling in your March issue, we consider to be incorrect when it is stated without reservation that neutralization of impulsive interference is effected across the common load resistance of the diodes. This is true during the sync period; i.e., when the fly-back has been initiated and point B (B. T. Gilling's Fig. 2) is neutral, but prior to the sync pulse the circuit does not appear to be immune to noise. For example, during the period between the middle and end of the scan, point B is negative and thus noise spikes appearing 180 degrees out of phase at V2(a) and V2(b), anode and cathode respectively, will result in the greater conduction by V2(a), and hence a positive signal voltage developed across the common load.

The operation of the d.c. amplifier, as shown in Fig. 5, is obscure, since the valve is without cathode bias and will be driven by positive excursions during the sync period into grid current which can find no d.c. path to cathode.

We support your correspondent in identifying the circuit as a phase discriminator, and it is to be hoped that the discriminator as used in frequency modulation applications, which for so long has assumed a similar identity, will be regarded more correctly as a frequency discriminator. W. J. CROSSLEY, S. L. FIFE.

English Electric Company, Liverpool.

Lamp Interference

THE problem of lamp interference, raised by K. Robinson in your May issue, is quite well known, though it does seem extraordinary that a lamp with a continuous filament can give trouble.

Whilst the complete mechanism is, so far as I know, not fully understood, it is quite normal for vacuum lamps to act as quite powerful energy generators, and interference from them can cover a range of at least ¼-mile.

The functioning of a lamp as a r.f. generator, and the frequency, depends on instantaneous voltage, and thus when a.c. is used the interference only occurs on certain parts of the voltage cycle, and the frequency also varies, this accounting for "herringbone" and similar effects.

Luckily, this phenomenon is restricted to vacuum lamps normally of 25 watts or more, and these lamps are only used in special installations, such as traffic signs and "keep left" bollards, and are not on sale to the general public. The "gasfilled" lamp is quite innocent.

Enfield, Middx. A. P. HALE.

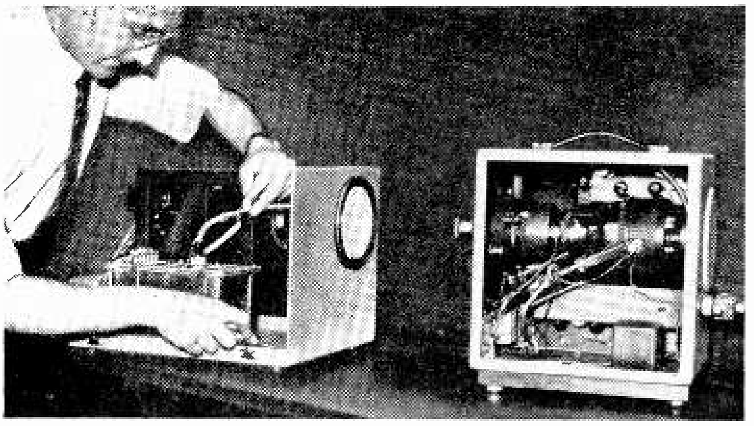
"*Designing a Tape Recorder*"

REFERRING to the above article in your April issue, I should like to make two further suggestions for a level monitor. Both incorporate the refinement, particularly desirable in home-built equipment, of monitoring bias oscillator and audio output voltages simultaneously.

The first uses the two meters from an aircraft direction indicator (see *Wireless World* article of September, 1951, and remember the warning about beta radiation—January, 1952). Each meter is put in a bridge rectifier circuit which is fed through a high resistance from either the erase oscillator or the anode of the audio output valve. Because of the high sensitivity of these meters, there is no trouble concerning the load they will put on the two outputs.

The second method is very suitable if a 500-volt h.t. line is available. A 1CP1 type cathode ray tube is used as the indicating device, the oscillator volts being fed across one set of plates whilst the audio output is fed across the other. This gives a rectangular fluorescent area the width of which is proportional to oscillator output and the depth to audio output.

Cussins and Light, Ltd. W. D. CUSSINS.
York.



Television Standards Converter

Mobile Equipment in Holland for the Coronation Relay

READERS will see from our route map of the Coronation relay to Europe (following page) that the British 405-line signals are converted to the continental 625-line standard at Breda in Holland. The converter equipment, designed by the Philips Research Laboratories at Eindhoven, is basically the same as that used by the B.B.C. at Cassel last year for changing from French to British standards—a c.r.t. monitor displays the incoming picture and this is viewed by a camera working on the new standards. The situation is rather different at Breda, however, in that the pictures are going in the opposite direction and are being converted from a low number of lines to a higher number of lines. Moreover, the equipment is a good deal smaller than the B.B.C.'s, and is actually installed in a trailer—which also contains a reserve converter (in case of breakdowns) and a quantity of monitoring and test gear. This trailer is stationed outside a church known as the Grote Kerk in Breda, and from it cables run up the side of the building to the centimetre-wave transmitting and receiving equipments which are mounted on the steeple.

The smallness of the converter has been achieved mainly by the use of a c.r. tube with a screen diameter of only 5in to display the incoming picture. Normally, with a screen of this diameter, the definition would not be very good because of the relatively large size of the spot; but the tube is actually a flying-spot scanner with a very small spot and has a definition of 1,000 lines. The camera has an image iconoscope pick-up tube, and this is fitted with a mask at the edge of its viewing window to provide a black reference for the 625-line signal.

As in previous converter equipments, the monitor c.r. tube uses a long-persistence screen as a means of light storage. Without this, the camera pick-up tube would tend to act as a simple photo-cell and would respond to the instantaneous variations of intensity of the light spot. Thus it would produce a spurious waveform corresponding to the 405-line vision signal, and this would beat with the normal 625-line signal to give a completely meaningless output. With the long-persistence screen, however, a large component of unmodulated light is introduced, so that the intensity variations of the spot are made negligible in comparison and have little or no effect on the pick-up tube.

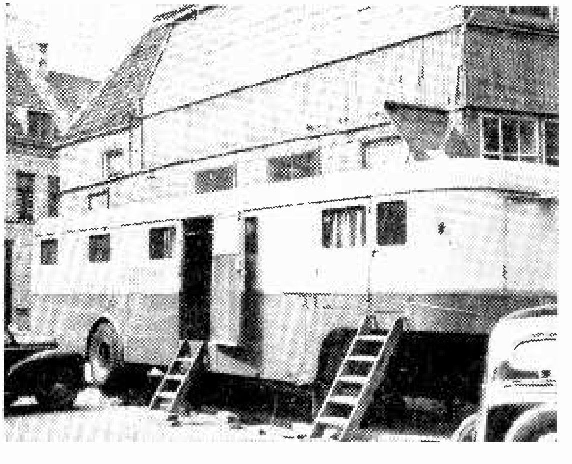
At the same time, of course, the persistence must not be made long enough to preserve one picture into the next picture period, otherwise blurring would occur with moving images Actually the decay characteristic of the phosphor is such that the brightness of a point on the screen falls to about ⅞ths of its original value by the end of one frame period.

Another important point is that the scanning beam of the camera is arranged to "read" the picture at a more-or-less constant time interval behind the "writing" spot of the c.r. tube. (This is possible because, although the line periods of the two systems are different, the frame periods are the same.) If this were not done there would be a phase drift between the two scanning systems, and sometimes the camera would be "reading" the picture while it was still bright from the spot and sometimes while it was fading out a long way behind the spot, and the result would be that the outgoing picture would fluctuate in brightness. The two scanning systems are actually locked together by synchronizing the camera waveform generators with the frame sync pulses of the incoming 405-line signal.

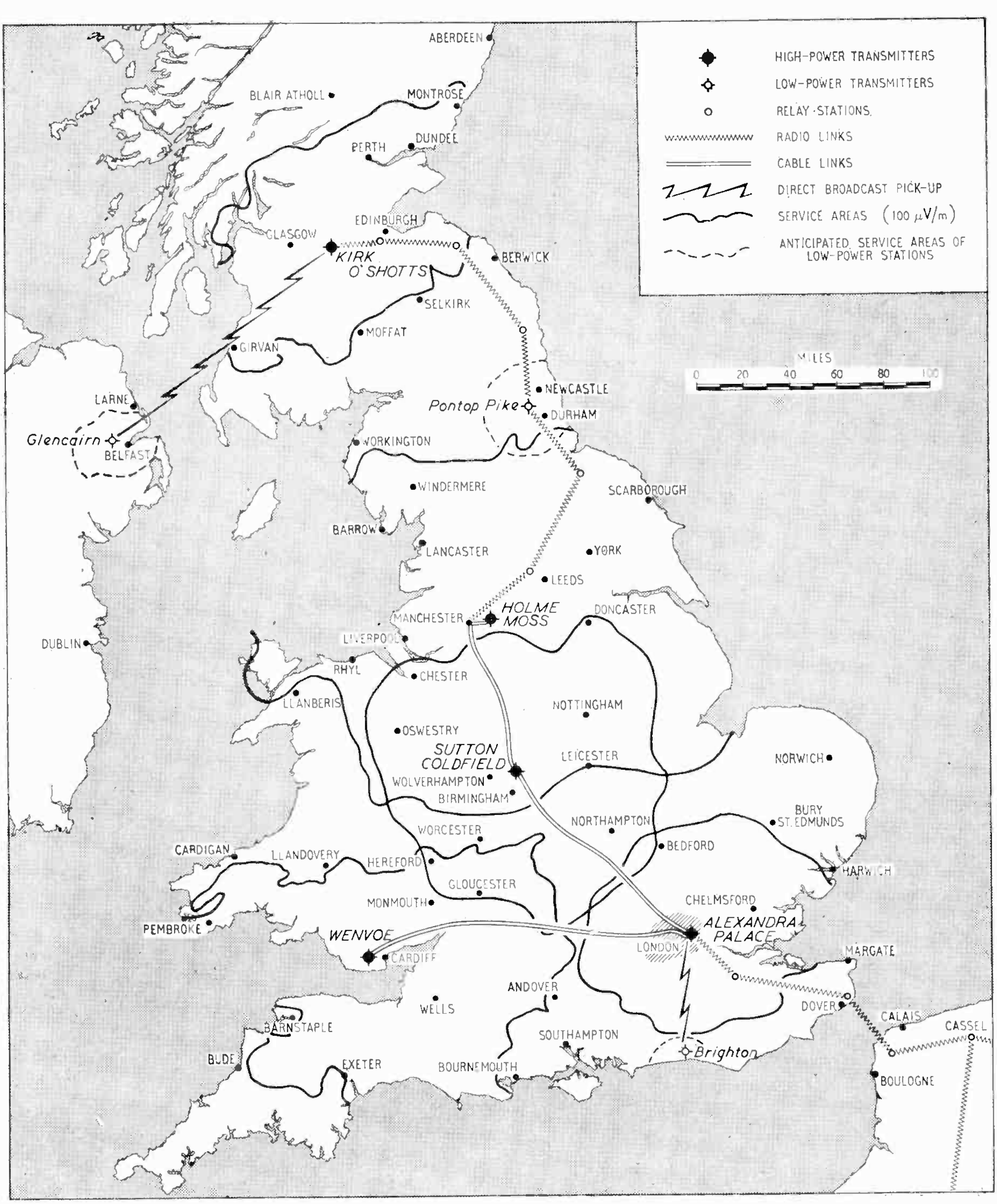
Since the conversion is from a low number of lines to a higher number, it has been necessary to "fill in the gaps" in the 405-line picture by spot-wobbling. Without this device, the scanning lines of the camera would sometimes coincide with those of the 405-line picture and sometimes fall between them, and an interference pattern would appear on the outgoing picture.

Recently *Wireless World* had an opportunity of seeing the converted pictures at Amsterdam, after they had been transmitted from Lopik, and we were agreeably surprised by their quality. Inevitably there was some degradation, but not enough to worry the average viewer, and we have seen worse on receivers in this country.

The converter equipment, with the monitor unit on the left and the camera on the right, is shown above, and below is the trailer in which the equipment is installed.



International Television: *Radio and*



With the recent opening of the temporary, mobile, low-power television stations at Glencairn (Belfast) and Pontop Pike (Newcastle) and the booster station near Brighton, approximately 80% of the population are now within the B.B.C. television service area, indicated on this map by the 100µV/m contours. The estimated coverage of the Glencairn transmitter, which relies on its direct reception of Kirk o'Shotts, is Belfast and its immediate surroundings. Using the permanent aerial, Pontop Pike serves an area within a radius of approximately 20 miles of the transmitter. The Brighton booster station, which re-transmits the Alexandra Palace transmission, is intended to serve the town and district.

Cable 2,000-mile Network for the Coronation Transmissions

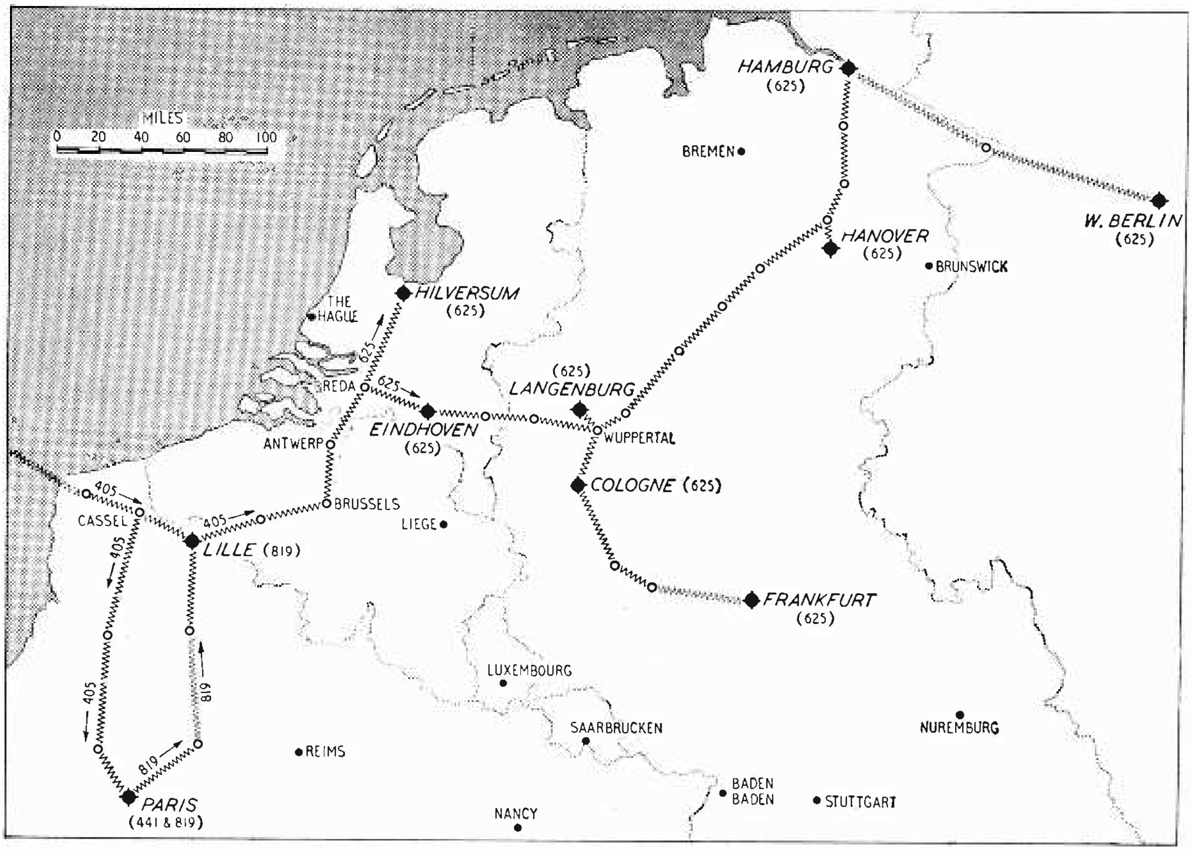
THE international exchange of television programmes has been brought a stage nearer by the unqualified success of the recent tests conducted on the Continent, preparatory to the re-radiation of the B.B.C. Coronation day transmissions by stations in France, Holland and Western Germany. On these two pages we reproduce sketch maps of the British Isles and northern Europe showing the 2,000-mile radio and cable network which will convey the B.B.C. television transmissions on June 2nd to viewers in four countries. On the opposite page is shown the complete chain of British television stations, the methods of linking and the service areas of each of the five high-power and three low-power transmitters now in use.

For the continental relay the vision signal will be transmitted from London to France by relay stations provided by Standard Telephones & Cables, Ltd. It will be picked up at a point near Cap Blanc Nez, Calais, and re-transmitted to Cassel. It will be seen from the map that the 405-line signal is carried by the French P.T.T. and Radiodiffusion et Télévision Françaises south from Cassel to Paris for conversion to 441 and 819 lines for re-transmission by Paris and Lille. The 405-line signal is also carried east from Cassel to Lille where it is conveyed over a chain of centimetre-wave links across Belgium, which has not yet a television service. It is, however, planned to monitor the transmission in Brussels where a limited number of people will see the 405-line picture probably on large-screen equipment.

The key point for the 625-line transmissions by the Dutch and West German stations is Breda, where, as described on page 273, the Philips organization has set up a conversion unit. The 625-line signal will be taken by direct links to Hilversum and Eindhoven and via four centimetre-wave relays to Wuppertal to be fed into the permanent network recently inaugurated by the Nordwestdeutsche Runfunk to link the five N.W.D.R. television stations. The longest hop in this chain of relay stations is that linking the Berlin transmitter with the last station in Western Germany—a distance of nearly 100 miles. The frequency used for this hop is 196.25 Mc/s. In addition to the five N.W.D.R. stations the Frankfurt transmitter in the American Zone and possibly the Weinbiet station near Baden Baden (French Zone) will be radiating the 625-line transmission.

The complementary sound transmissions will be carried by cable to the Continent, where broadcasting organizations will have the choice of two of the following three circuits: 1, background sound free from any commentary; 2, English commentary; and 3, French commentary. It will, therefore, be possible for Dutch and German commentators to hear the English or French commentary which they can then translate for superimposition on the background sound.

Centimetre-wave links covering some 1,200 miles form the chain for the re-transmission of the B.B.C.'s Coronation day broadcasts by Continental television stations. Against each transmitter is indicated the standard employed.



Improving the Dry Cell

Making Better Use of the Raw Materials

By R. W. HALLOWS, M.A.(Cantab), M.I.E.E.

WHEN zinc was plentiful and little accounted, a run-down dry battery, whose cell-cans might still contain from two-thirds to four-fifths of their original weight of the metal, could be thrown light-heartedly into the dustbin. To-day, there is a world shortage of zinc, and it is a matter of some importance that it should not be used wastefully. The dry Leclanché cell, which has proved itself to be the most convenient, the least messy and the most foolproof source of what the late Dr. C. F. Burgess aptly termed portable power, is nowadays one of the major callers on the world's zinc supplies, for the number of such cells in use at any moment runs into astronomical figures. Apart from the fact that most of the world's homes are now within range of some source of broadcast entertainment, and that the majority are still without mains supplies of electricity, portable wireless receivers of various kinds enjoy wide popularity; much of any army's wireless equipment must be battery-operated; hearing-aid appliances, developed from the a.f. side of the wireless receiver, are being used in larger and larger numbers. If one thinks, too, of the flashlamps, the cycle lamps and other small electrical appliances used now by millions of people in all parts of the world, it is quickly realized that the term astronomical is no exaggeration when applied to the number of dry cells in use the world over at any time.

The purpose of the present article is to investigate the efficiency, or otherwise, of the dry cell as we know it and to suggest ways in which its design, composition and construction might be improved. A second article will deal with the possibilities of using relatively cheap power from the supply mains to bring dry cells after discharge back to something like their original condition.

As almost everyone knows, the Leclanché cell "generates a current of electricity by consuming zinc as a fuel." Or, to put it a little less unscientifically, such a cell maintains a flow of electrons through an external closed circuit by converting into electrical energy the chemical energy involved in the recombination of ammonuim-chloride and zinc into zinc-chloride, ammonia and hydrogen. As the textbooks have it,

$$2NH_4Cl + Zn = ZnCl_2 + 2NH_3 + H_2.$$

That is a considerable over-simplification, for every manufacturer has his own pet electrolyte, which may contain calcium, lithium, magnesium, zinc and possibly other metals in the form of chlorides. This, however, is not the place to discuss such a complex matter, and we may accept for working purposes that the primary reaction is on these lines.

Depolarizing Process

The word "primary" is used because the cell is really a two-part affair. Part 1 consists of the electrolyte and the zinc, between which (on open circuit) there is a potential difference of about 1.1 volt. This portion is very efficient, in so far as it does not suffer from polarization: it gets rid of its surplus hydrogen in the form of positive ions. In Part II we have a p.d. of 0.4 V between the carbon and manganese-dioxide element and the electrolyte; hence the overall open circuit p.d. between the terminals of the cell is about 1.1 V + 0.4 V = 1.5 V. But in this second part of the cell we run into considerable trouble when the external circuit is closed.

Each positive hydrogen ion, on reaching the carbon element, exerts an attraction which causes one electron to leave the negative pole, to travel through the external circuit and to turn the positive ion in question into a neutral hydrogen atom. Were nothing done about it, the carbon would soon be surrounded by a blanket of inert hydrogen molecules. Part II of the cell would be clogged and the action of Part I would also be brought to a standstill, for it would no longer be able to discard its surplus hydrogen ions.

Many textbooks lightly show the action of the man-

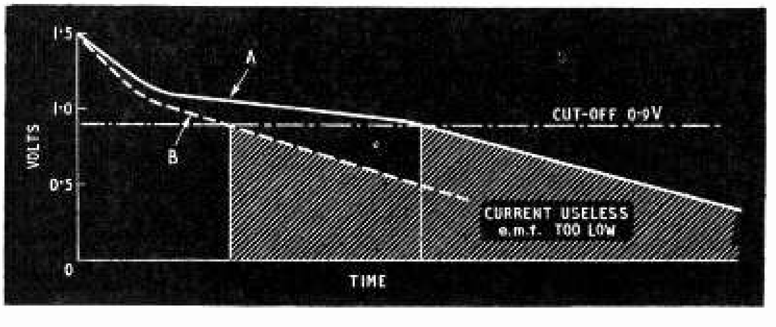


Fig. 1. Curve A shows typical end voltages during intermittent discharge of high-grade cells under ideal conditions of load, temperature and rest periods. A considerable proportion of the ampere-hours potentially available from the zinc in the can is useless, since the e.m.f. is too low. B is the discharge curve of moderately good cells under similar conditions.

ganese-dioxide depolarizer usually employed as:

$$2H + 2MnO_2 = Mn_2O_3 + H_2O$$

If that were a complete statement of the case polarization would be eliminated; or, in any event, complete depolarization, with a return to its original e.m.f., would occur in a cell "rested" for a short time. That this does not happen is common knowledge. The reactions involved are far more complicated. It would be nearer the truth to write: "In time, a certain amount of the hydrogen molecules become dissociated into ions and some of these react with some of the manganese dioxide to form another oxide of manganese and water. Other slow and complex reactions are involved, and this process of depolarization is never sufficiently rapid to keep pace with the clogging that takes place during discharge, or complete enough to restore the original load e.m.f., no matter how long the cell is rested."

Now let us see how effectively the zinc is used. My experiments were made with cells of the $1\frac{1}{4} \times 2\frac{1}{4}$-inch size. Each maker has his own designation for these. The Ever Ready "U2" will be familiar to most readers and will be used as a general term, though cells of a number of different makes, British and American, were subjected to the series of tests on which the present articles are based. The cans of such cells vary somewhat in weight from make to make; nor is it always easy to determine the exact weight of zinc, for seamed cans contain a certain amount of solder. Some cans are thicker than others and there are slight variations in dimensions. On the whole, though, we shall not be far out if we put the average weight of zinc in cans of this size at 19 grams.

There is no difficulty about discovering the number of ampere-hours of current which 19 grams of zinc would furnish, could it be used with complete efficiency. An ampere is a flow of one coulomb a second, and a coulomb consists of 6.3×10^{18} electrons. Zinc is bivalent; each atom passing into the electrolyte is a doubly positive ion, Zn^{++}. This means that for every zinc atom removed from the can two electrons are available at the negative terminal of the cell. To maintain a current of one ampere, then, 3.15×10^{18} atoms must leave the can every second. The atomic weight of zinc is 65.38 (O=16), and from Avogadro's Number we know that 65.38 grams of zinc contain 6.0234×10^{23} atoms. Hence the weight of 3.15×10^{18} zinc atoms is 0.000338 gram; and that is the electrochemical equivalent of zinc. Multiplying by 60×60, we have, in round figures, 1.2 grams of zinc per ampere-hour.

In other words, the current obtainable if 19 grams of zinc were used a hundred per cent efficiently, would be 15.8 Ah. Discharged under ideal conditions of load, temperature and time allowed for recuperation, average cells of "U2" size give 3-4 Ah, and those of the highest quality from 5.5 to a little over 6 Ah. In other words, cells in common use may turn only from 19 to 24 per cent of their zinc to good account, while for the very best the figure does not exceed 40 per cent.

Many factors contribute to this low efficiency. One of the most important of these is that most apparatus intended to be operated by dry cells is designed to work satisfactorily down to, but not below, an e.m.f. of 0.9V per cell. Curve A of Fig. 1 shows typical lumped end voltages (that is, the average e.m.f.s at the end of each day's run) of a group of first-rate cells, discharged under the ideal conditions mentioned. It will be seen that much of the current potentially available from the zinc is useless, since the e.m.f. has fallen below cut-off as a result of progressive polarization. The first requirement, then, if cells of high quality are to be made more efficient, is to speed up the depolarizing process and to make it more thorough. Possible means to this end will be considered later. Curve B of Fig. 1 shows the curve for moderately good cells, discharged under similar conditions.

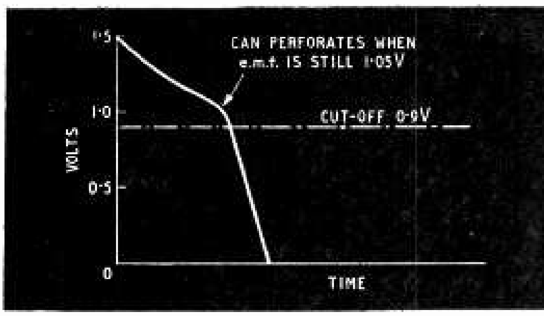


Fig. 2. Discharge curve showing the effects of perforation of the can at a moment when the e.m.f. is still 1.05V.

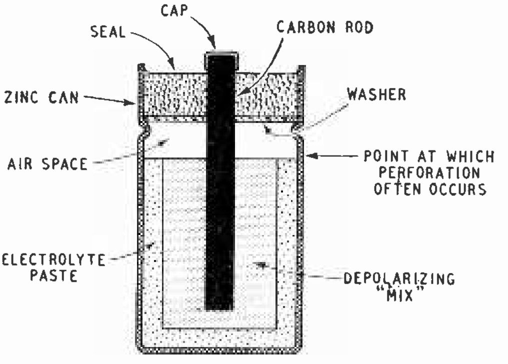


Fig. 3. Construction of modern dry cell. It will be seen that no sac is used. Perforation often occurs in line with the top of the electrolyte paste.

Though their overall performance is poor, the cells are classed as moderately good because they do not show one shocking and all-too-common fault; perforation of the can when the e.m.f. is still above (sometimes well above) cut-off. Fig. 2 indicates what happens in such cases. The e.m.f. begins to fluctuate and then falls almost like the proverbial stone. The electrolyte paste oozes from the hole in the can and may do serious damage. Perforation of one or more cans is in my experience one of the commonest causes of the breakdown of h.t. batteries. I have many times known it occur in batteries which had till then been giving readings of from 0.95V to 1.15V per cell. A curious point is that the cans perforated are nearly always near the middle of the battery; that is, in an 80-cell (120-volt) battery untimely perforation is most liable to occur between the 20th and 60th cells from the negative end.

Causes of Perforation

Premature perforation is in most instances due to poor design or construction. Fig. 3 (which may come as a surprise to any who have not examined the inside of a dry cell for some time) shows how most of these cells are made to-day. There is no sac, the depolarizing "mix" being in direct contact with the

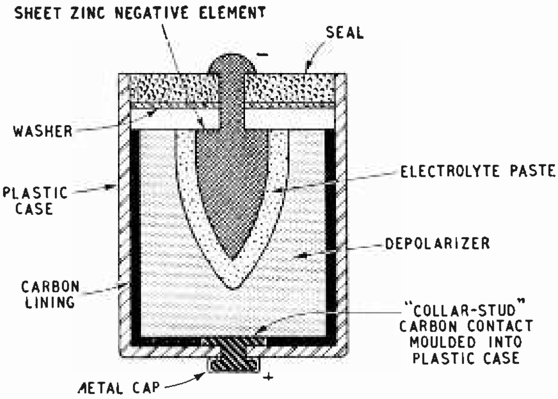


Fig. 4. Suggested "inside-out" cell. Only a small part of the zinc used is now unemployed. By designing the cell so that the carbon forms a lining to the plastic container, the depolarizer is given a much larger surface area on which to act.

paste electrolyte. As Fig. 3 indicates, a position at which the first signs of perforation very often occur is in the part of the can on a level with the top of the electrolyte. When a cell which has failed in this way is opened one frequently finds evidence of a considerable amount of "creeping" of salts from the electrolyte in the vicinity of the puncture. Small differences in the concentrations of such salts may give rise to undesirable local action.

Creeping does not occur to any marked extent inside really good dry cells. It may be due to one of two causes, or to both together. The first of these is the use of too strong a concentration of sal-ammoniac in the electrolyte; the second is failure to make the seal perfectly air-tight. These two causes are probably inter-connected. When a cell is not air-tight, evaporation takes place from the electrolyte, with the result that the ratio of sal-ammoniac to water increases. Another cause of the perforation of cans before cut-off e.m.f. is reached, is the use of zinc of too light a gauge.

There is another important reason why a considerable amount of the zinc in the can is not available for the production of current. A glance at Fig. 3 will show that all that part of the can which surrounds the air-space, the washer and the seal is out of the running: it is merely acting as part of a container and has no electrical role. Again, there is very little electro-chemical action at or near the bottom of the can; and here again zinc *as* zinc is mainly wasted.

New Design of Cell

Could not the dry cell be entirely redesigned on lines more in keeping with the present availability of raw materials? I think I am right in saying that, when the first dry cells were made, suitable carbon was most readily obtainable in the form of rods or plates. Zinc being then plentiful and cheap, the line of least resistance led to the familiar design of the dry cell. Great changes have occurred in the sixty-odd years that have passed since these cells began to come into anything like general use—changes, that is, in everything except their general make-up. High-density carbon, for example, is now readily shaped—or deposited—in any required way.

It is some time now since it occurred to me that a good many advantages might accrue, were the dry cell turned, so to speak, inside out. I have not the facilities for making up the dry cell illustrated in Fig. 4—or, for that matter, any kind of dry cell. But experiments made with wet Leclanché cells using carbon elements of large area have given very promising results. The main purpose of these has been (a) to put the zinc element where the greatest possible proportion of it plays a useful part; (b) to provide the depolarizer with the largest possible surface of carbon on which to act; (c) to make the greatest use of cheap and easily obtainable materials; (d) to evolve a cell which cannot play havoc by perforating; and (e) to produce a cell of exactly the same dimensions as the zinc-cased cell and fitting into any apparatus designed to be operated by it.

Fig. 4 illustrates more or less diagrammatically the suggested new look for the dry cell. The case is of plastic and into the bottom is moulded a "collar-stud" carbon (or metal) contact, with a metal cap on its external end. Immediately inside the case is a thin carbon lining; it need not be more than a few hundredths of an inch in thickness, for in the cell the carbon is chemically inert.

The zinc element is hollow and made of sheet metal, possibly perforated. Or again, it may be a finned die-casting. Its exact shape and mass must be the subject of experiments. The zinc is "pasted" with electrolyte in the ordinary way. The parts between the electrolyte and the button forming the negative contact are protected from chemical and electro-chemical action by a plastic coating.

. . . And its Advantages

A cell made on the proposed lines cannot perforate; by far the greater part of the zinc is usefully employed; polarization must be much slower and depolarization quicker and more complete owing to the far larger area of carbon over which the hydrogen ions are distributed and on which the depolarizer is free to act. The surface area of the carbon walls is actually more than four times greater than that provided by the rod element now used. It will be seen that the proposed cell appears to be also inside-out, or perhaps one should say upside-down, as regards the polarity of its terminals. That protruding from the seal is the negative, while the cap at the bottom is the positive. This, however, is not a matter of importance, so long as the terminals are plainly marked + and −.

Though the idea of designing a dry cell on the lines described was original, in so far as it was based on my own line of thinking and on nothing that I had read, seen or heard, I cannot claim to be first in the field in trying to make the dry cell more efficient by turning it inside-out. Somebody always seems to have thought a little sooner than oneself of any new conception that occurs!

Explaining my scheme recently to an American friend, I learnt that an "inside-out" dry cell had made its appearance in the United States. I have not been able to acquire American cells of this type, or to find out anything more about them. Whether or not they bear any resemblance to the design suggested in Fig. 4 I do not know. What I venture to hope is that this article may stimulate British designers of dry cells to break away from tradition and to give us (and the all-important export market) something far more efficient and more economical than the familiar dry cells of to-day.

VORTEXION TAPE RECORDER

FEATURES WORTH NOTING . . . . . .

★ Extremely low distortion and background noise, with a frequency response of 50 c/s.–10 Kc/s., plus or minus 1.5 db. A meter is fitted for the measurement of signal level and bias level.

★ Sufficient power is available for recording on disc, either direct or from the tape, without additional amplifiers.

★ The 15 to 30 ohms microphone balanced line input is fully loaded with 20 microvolts.

★ Input 1, which requires 35 millivolts on .5 megohm, is suitable for crystal P.U.s, microphones or radio inputs.

★ A power plug is provided for a radio feeder unit, etc. Variable bass and treble controls are fitted for control of the play back signal.

★ The power output is 3.5 watts heavily damped by negative feedback and an oval internal speaker is built in for monitoring purposes.

★ Facilities are provided for using the amplifier alone and using power output or headphones while recording or to drive additional amplifiers.

★ Total power consumption is approximately 50 watts.

★ The hum and noise level which was already very low has been still further reduced.

The amplifier, speaker and case, with detachable lid, measures $8\frac{1}{4}$in. x $22\frac{1}{2}$in. x $15\frac{3}{4}$in. and weighs 31 lb.

PRICE, complete with WEARITE TAPE DECK £84 0 0

POWER SUPPLY UNIT to work from 12 Volt Battery with an output of 230v., 120 Watts, 50 cycles within 1%. Suppressed for use with Tape Recorder. **PRICE £18 0 0.**

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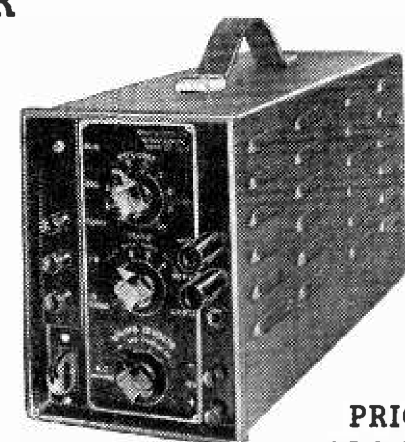
For A.C. Mains and 12 volt working giving 15 watts output, has switch change-over from A.C. to D.C. and "Stand-by" positions. Consumes only $5\frac{1}{2}$ amperes from 12 volt battery. Fitted with mu-metal shielded microphone transformer for 15 ohm microphone, provision for crystal or moving iron pick-up with tone control for bass and top. Outputs for 7.5 and 15 ohms. Complete in steel case with valves.



PRICE £30.16.0

Manufactured by

VORTEXION LIMITED, 257-263, The Broadway, Wimbledon, London, S.W.19

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MODERNIZING THE

Wireless World Television Receiver

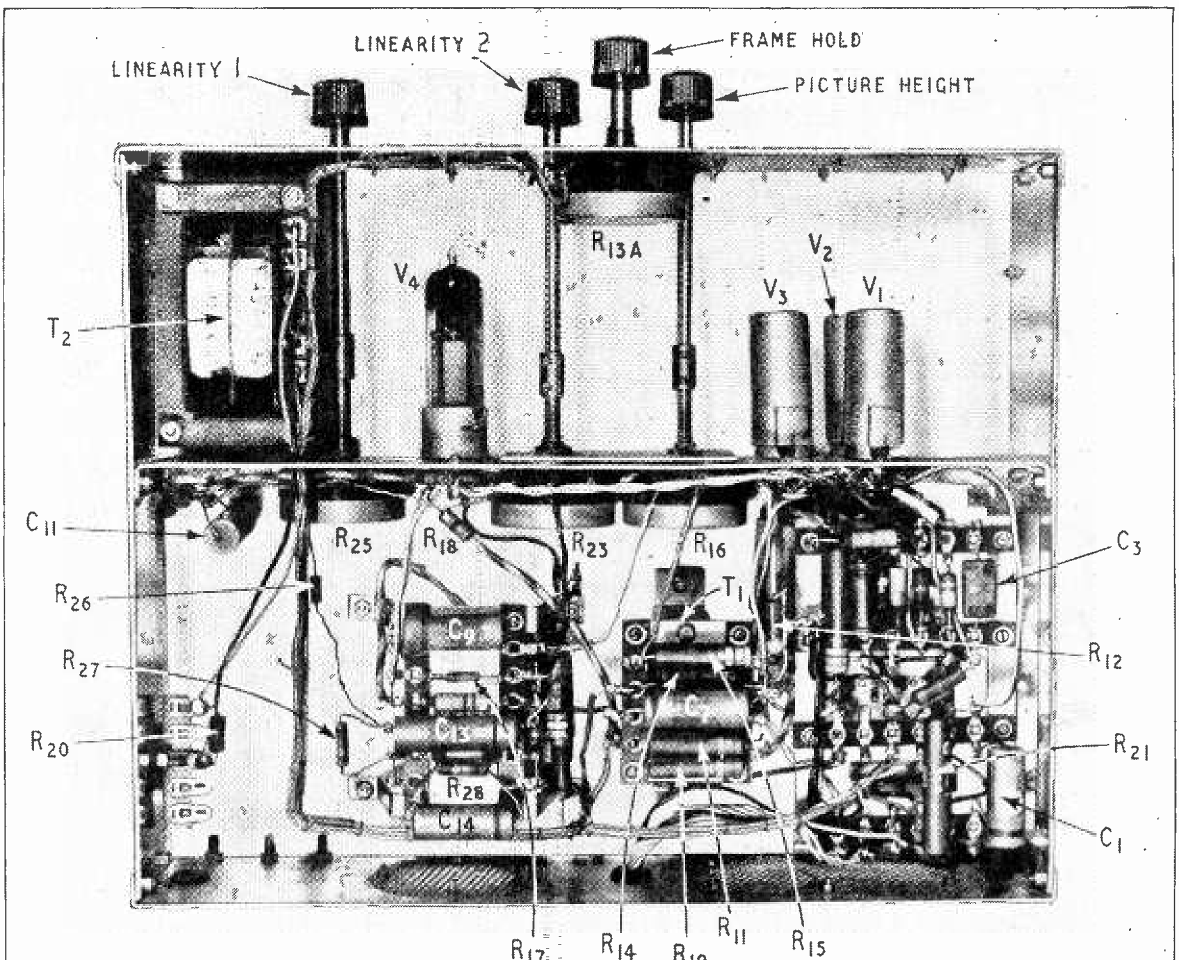
Part 2.—Time-Base Circuits

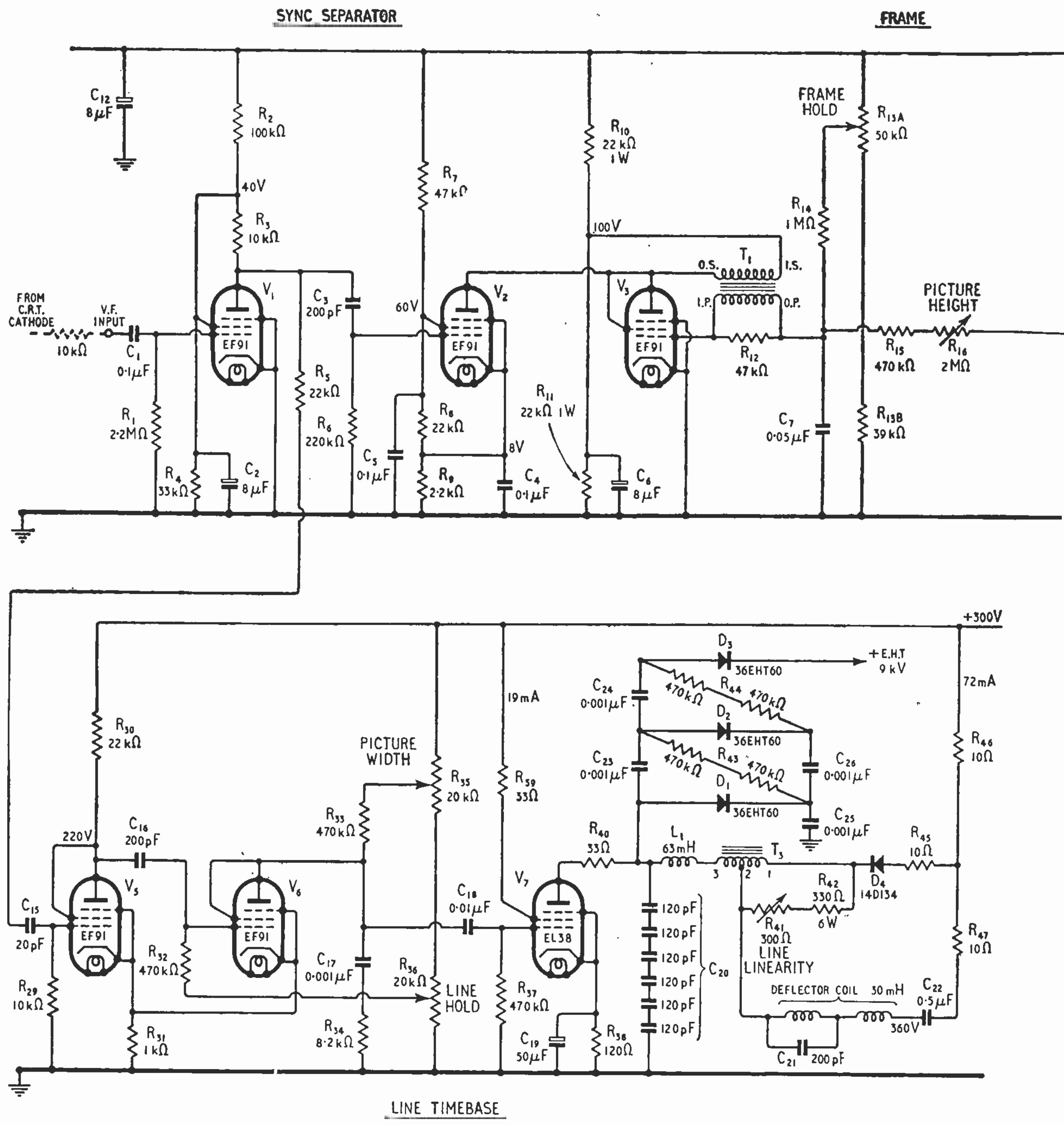
IN the original *Wireless World* Television Receiver the frame and line time-bases were built on two separate chassis and the sync-separator circuits were included with the frame time-base. A similar arrangement is adopted for these new time-bases and the sync-separator is included with them.

The circuit diagram is shown in Fig. 1. V_1 is the sync-separator and is fed with the combined sync and picture signal from the cathode of the tube. It is actually fed through a 10-kΩ ½-W resistor suspended in the lead from the tube cathode to the sync-input connector on the time-base. This resistor is shown dotted in the diagrams to indicate that it is external to the chassis. In the original time-bases, C_1 was so mounted and can be still if desired, but it is normally convenient to include it in the chassis. It must be so mounted that it has a low stray capacitance to earth.

D.C. restoration is effected in the grid circuit in the usual way and the separated negative-going sync pulses appear in the anode circuit. They are applied

Internal view of the frame time-base unit with some of the chief components indicated. The sync-separator components are on the extreme right.





through a differentiator and attenuator R_5, C_{15}, R_{29}, to V_5 of the line saw-tooth generator. They are also applied through a semi-differentiator C_3, R_6, to the limiter V_2 which produces sharp output pulses from the trailing edges of the frame pulses. These are negative-going and are applied to the anode of the frame saw-tooth generator V_3.

This generator is a blocking oscillator using a transformer T_1. This transformer is identical with the one used in the original receiver. The saw-tooth appears across C_7. Instead of using a variable charging resistance for the Hold control, the charging resistance R_{14} is now fixed and is taken to a variable voltage point provided by R_{13A}. The main reason for this is that a lower value variable component can be used and therefore one which can be wire-wound.

The saw-tooth voltage across C_7 is fed to the grid of V_4, the frame output valve, through R_{15} and R_{16}, the latter of which is variable as a Height control. The deflector coil is transformer-coupled to the valve by T_2 and the 150-Ω resistance R_{20} across the deflector coil is for the purpose of reducing the line-frequency voltages set up in the deflector coil by unavoidable coupling to the line deflector coil.

Since it is not possible to make the inductance of the transformer anything like high enough to avoid

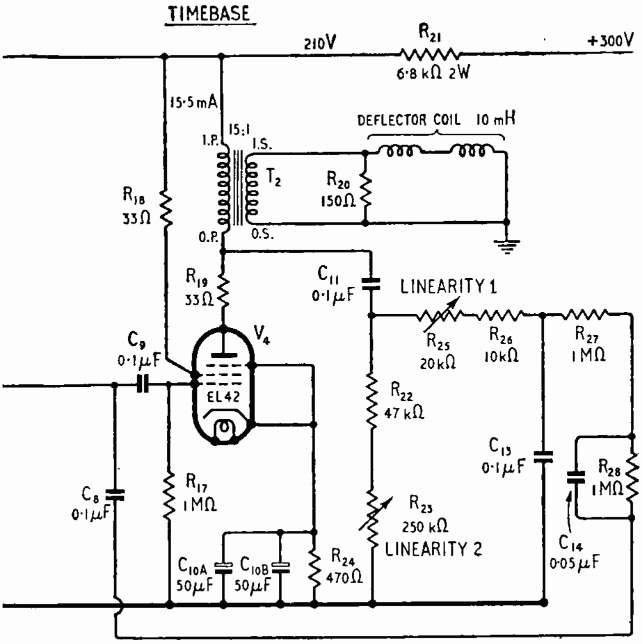


Fig. 1. Complete circuit diagram of the new time-bases. The resistor shown dotted is mounted in the wiring between the tube cathode and the input to the sync separator. C_{21} is mounted on the deflector-coil assembly. R_{45}, R_{46} and R_{47} have no circuit function but are included merely so that the current waveforms can be checked easily with an oscilloscope.

severe waveform distortion, very heavy correction is needed to obtain linearity. This is obtained by a feedback circuit of the Blumlein type. There are in all four circuits introducing distortion of the same form; the initial charging circuit R_{14}, C_7, the coupling R_{17}, C_9, the cathode-bias circuit R_{24}, C_{10}, and the transformer coupling. The transformer is the major source of distortion and the bias circuit the next in importance.

The correction circuit comprises C_{11} with R_{22} and R_{23}, the latter being variable as a linearity control. It is the main such control and affects the linearity generally over the picture. The next elements R_{25} and R_{26} with C_{13} affect the linearity at the extreme top of the picture only. In practice, R_{25} opens or closes the top half-inch of the picture. The remaining components R_{27}, R_{28}, C_{14} and C_8, are unusual ones, but were found experimentally to improve the linearity at the extreme bottom of the picture.

The linearity is affected by valve curvature, and so the settings of the linearity controls are slightly affected by the Height control. The dependence is small, however, and causes no practical inconvenience. In initial setting up the Height control should be adjusted for a picture of about three-quarters normal height and the two linearity controls roughly adjusted. Height should then be increased until the picture is just a little smaller than the mask and the linearity controls finally adjusted. Linearity 1 can easily be adjusted at any time for uniform line spacing at the top of the picture. Linearity 2 should be adjusted on Test Card C if possible. Height can then be increased to the proper value

A very hard frame lock is usually obtained, with the result that over a large part of its range a variation of Hold only affects the picture Height. Usually it is sufficient to set Hold at about the middle of the hold range and leave it there.

In the line time-base the saw-tooth generator is a cathode-coupled multivibrator V_5, V_6. The charging capacitance is C_{17} and the charging resistance is R_{33}. The applied voltage is varied by R_{35} as a width control. This varies the amplitude of the generated saw-tooth and hence the drive on the output valve V_7.

The valve V_6 is normally held beyond cut-off by the charge on C_{16}, thus enabling C_{17} to charge. V_5 is conductive. A negative-going sync pulse on the grid of V_5 reduces its anode current and causes a rise of voltage on its anode which is passed to V_6 by C_{16}. This makes V_6 conductive and its anode current is drawn from C_{17} to discharge it. Grid current also flows to charge C_{16}. These currents flow through R_{31} and raise the cathode potential of both valves, which still further reduces the current in V_5. The action is regenerative. When C_{17} is discharged, the current in V_6 drops and so the cathode potential falls and the current in V_5 rises. The action is again regenerative and V_6 is cut off. It is held cut off by the charge on C_{16} until the next sync pulse comes along or until C_{16} has discharged sufficiently to let V_6 conduct again. The grid-return potential of V_6 is adjustable by R_{36} as a hold control.

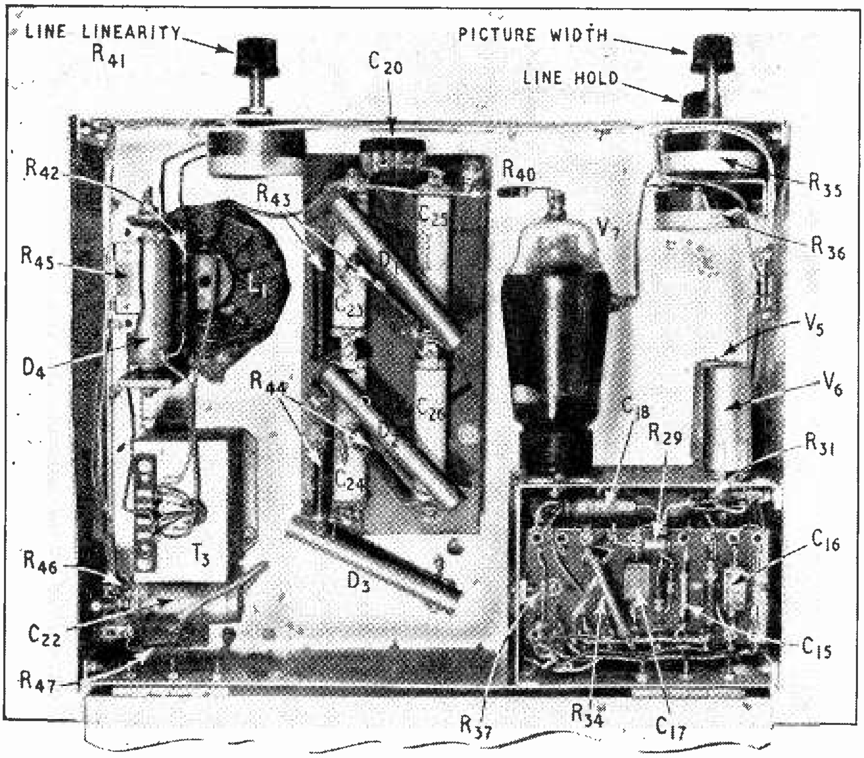
A resistance R_{34} is included in series with C_{17} in order to produce a large negative-going pulse on flyback. This is necessary in order to cut off the output valve rapidly and hold it cut off during flyback. The value of this resistance has an appreciable effect on the e.h.t. voltage produced and some effect on the linearity at the start of the scan.

No coupling transformer is used between the valve and the deflector coil and the circuit is one using a resonant flyback with an energy-recovery diode. Because of losses, the natural overshoot is less than 100%, and to obtain h.t. boost either a step-down transformer must be used or energy must be fed into the deflector-coil circuit during flyback so that the overshoot does become 100%. This energy is derived from a second circuit comprising L_1 and stray capacitances which is coupled to the deflector coil by C_{20}.

For a detailed explanation reference should be made to a previous article, but, briefly, L_1 and the deflector coil form two tuned circuits with their self- and stray-capacitances and they are coupled together by C_{20}, which acts as a "top-end" coupling capacitance. When V_7 is cut off during flyback, energy is stored in the magnetic fields of both coils. In the case of the deflector coil, it is required that the energy in its field be turned into electric form in the capacitance and then back again into magnetic form ready for the next scan. A loss of energy inevitably occurs, and this is made good by a transference of energy from L_1 through C_{20}.

The capacitance needed for this coupling is formed partly by the anode-cathode capacitance of V_7 and partly by a 20-pF capacitor C_{20}. This capacitor actually comprises six 120-pF capacitors in series, each of 750-V rating, in order to obtain the required voltage rating of 4 kV total.

A metal rectifier is used as a diode for energy recovery and avoids any difficulty over heater supply. It recovers about 50–60 V at the mean anode current of V_7 and this appears across C_{22}. With the 300-V h.t.



The line time-base unit. The e.h.t. voltage-tripler components are mounted near the centre on a sub-panel of Paxolin: slots are cut around the fixing holes to lengthen the leakage paths.

line the anode supply for the output stage is thus 350–360 V.

Linearity is controlled by the variable resistor R_{41}, which varies the magnitude of a control voltage injected by T_3 in series with the diode and derived from the anode current of V_7. This transformer is a simple scramble-wound component which needs no special insulation in itself and is, therefore, easy to make. As a whole it needs insulating for up to 2 kV from the chassis, because the peak voltage of the deflector coil appears on it. Magnetostriction in the core produces a whistle and the two are remedied together by enclosing it in sponge rubber to provide both electrical and acoustical insulation.

The resistors R_{45}, R_{46} and R_{47} have no circuit function. They are included merely to enable the current waveforms to be checked with an oscilloscope. If an oscilloscope is not used they need not be included. If they are employed they should be wire-wound resistors of 1% accuracy so that they can be used for actual measurement purposes. The mean anode current can be measured, for instance, by measuring the voltage drop across R_{45} or R_{46}. The reading in volts multiplied by 100 gives the current in milliamperes.

E.h.t. is obtained through a voltage-tripler rectifier system from the peak voltage which appears on flyback across L_1 and the deflector coil. The tripler gives a multiplication of about 2.5 times and produces some 8.5 kV from the 3.4-kV peak. The magnitude of the e.h.t. voltage is governed by the rate of cut-off of the output valve and by the value of C_{20}. Increasing the first by increasing R_{34}, and/or reducing C_{20}, will increase e.h.t. and, under some conditions, up to 11 kV has been obtained with full picture width. Generally speaking, if C_{20} is reduced, R_{34} must be increased to maintain linearity.

It is not recommended that these changes should be made, for the picture width becomes rather bare at voltages much over 9 kV and the full width may not always be obtainable. Also, difficulty from corona is likely.

Under the normal conditions of the circuit diagram, ample width is available with very good linearity and a complete absence of fold-over or visible ringing, and the adjustments are not critical. Normally the linearity control R_{41} should be set at about halfway and Width increased until the picture nearly fills the mask. Hold should be adjusted for a good lock, which will narrow the picture considerably. Then turn up Width again and re-adjust Hold. Adjust linearity on Test Card C. It is not a critical control. When R_{41} is too small the picture tends to be gradually compressed towards the right. As R_{41} is increased the linearity is improved and, if it is too high, it may expand towards the right. Adjust Width to the proper value and lastly, Hold.

A large range of width is available without losing synchronization but, after adjusting it, Hold should be readjusted because, even if synchronizing has not been lost, it may be nearly lost, and a slight change of mains voltage may send it over.

Some adjustment to C_{21} may be required. If this component is omitted, a series of grey and white bars will appear over the left-hand side of the picture. They are produced by ringing in the deflector coil itself and are quite independent of the time-base. They can only be avoided, in the absence of heavy coil losses, by equalizing the capacitances on the two coils of the line assembly. Ideally, C_{21} would be an adjustable component and would be adjusted to the critical value at which the bars disappear from the picture. In practice a suitable component is difficult to obtain, for it must be stable and withstand 1-kV peak. An approximate balance using a fixed capacitor has been adopted, therefore, with the result that the bars may not be completely absent.

The balance is normally good enough if the bars are just visible on a blank raster, for they are then unnoticeable on a picture. Precise adjustment of C_{21} will make them disappear even on a blank raster, but sufficient precision for this is hard to obtain without using an adjustable component.

This capacitor is not mounted in the chassis but directly on the deflector-coil assembly and across the "unearthy" coil of the line pair. If the deflector-coil connections as a whole have to be reversed, C_{21} must be changed over to the other coil.

Adjustment of C_{21} is best carried out on a blank raster, which need not be synchronized. Without it, a series of vertical grey and white bars on the left-hand side of the picture will be seen gradually decreasing in intensity towards the right and ceasing about the middle. As C_{21} is increased in value up to the optimum they decrease in intensity, but reappear again when it is too large.

In practice, if the bars are more than just detectable with a blank raster and a 200-pF capacitor, one should try different values for C_{21}. The first step is obviously to try an extra 20–30 pF capacitor in shunt with it, and to note whether this increases or reduces them. If it reduces them try a bit more, but if it increases them reduce the main capacitor to 150 pF and then start adding more capacitance.

The precise value for the complete elimination of the bars is quite critical. However, a value which renders them undetectable on anything but a blank raster is far from critical, and no difficulty should be experienced in finding one. If, by any mischance, the proper value cannot be found, it is a good plan to replace C_{21} temporarily by a variable air capacitor of 500 pF or so. This can be smoothly adjusted while watching the picture, and if a sharp balance point cannot be found, something is wrong somewhere.

Before turning to the constructional side it may be as well to say something about what parts of the original time-bases can be retained in making a change to the new one. The original sync-separator V_1 and V_2 can be retained unaltered with the original circuit values; but R_5, C_{15} and R_{29} of Fig. 1 must be included and have their new values. It may be found desirable in this case to reduce R_{29} to 4.7 kΩ, for the original sync separator gives a larger output than the new one.

In the frame time-base the EF37 can be retained for V_3 and the EL33 for V_4, but using all the new circuit values of Fig. 1. In the line time-base the EL38 is the only thing that can be retained. Although this has not been tried, it is probable that the EF50 can be used in place of the EF91 without change of values. A 6SN7 double-triode has been employed successfully in place of V_5 and V_6 without changing component values.

The use of an 807 in place of the EL38 has not been tried and can hardly be recommended. It has a screen dissipation rating of 3 W only, compared with the 6 W of the EL38, and its rating is therefore exceeded in this circuit. Apart from this, it would probably work satisfactorily but it might well have a short life.

The time-bases give ample scan for a tube operating at 8–9 kV, and this is an adequate voltage for a 12-in tube. Many will consider it enough for larger tubes, although the trend is to operate such tubes at higher voltages. The use of higher voltages is not recommended to the inexperienced, however, on account of the difficulty of avoiding corona troubles. These are

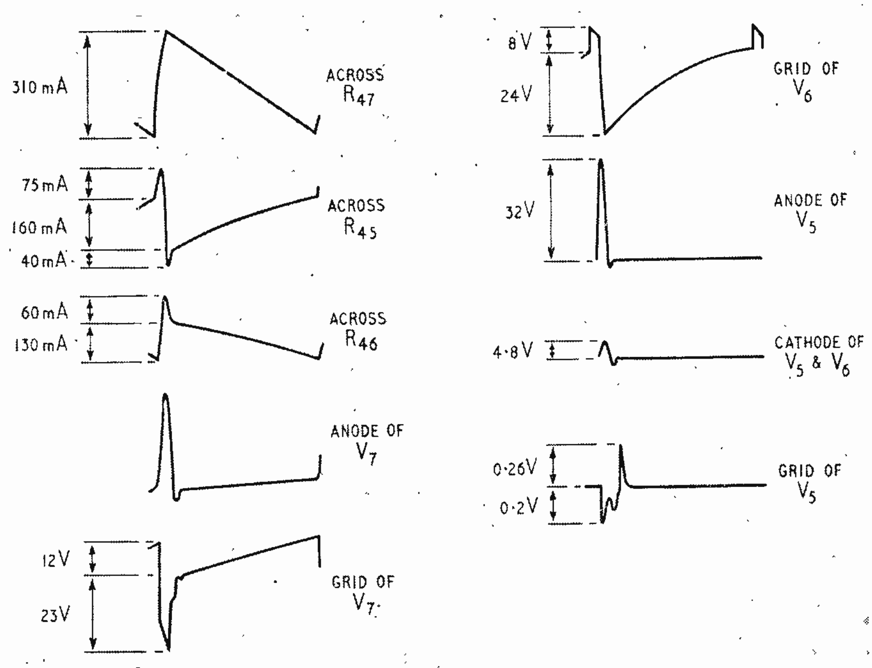
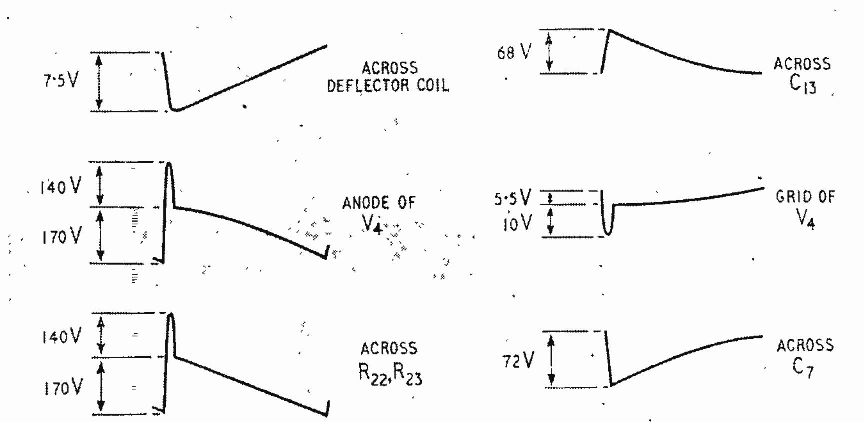


Fig. 2. Waveforms at important points in the line time-base. The current waveforms were measured as voltages across 10-Ω resistors.

Fig. 3. Waveforms in the frame time-base. A 10-MΩ resistor was connected to the oscilloscope cable to reduce small superimposed line-frequency voltages.



small for voltages below 8 kV, but become very considerable above 10 kV. In the region 9–10 kV corona can be troublesome, but is not unduly so. To minimize these troubles the voltage is limited to 9 kV in the present design and, allowing for the inevitable variations, may be 8 kV in some models.

It may be remarked in passing that a major effect of slight corona, which may be otherwise unsuspected, is poor line synchronizing. The discharge produces pulses which fire the time-base erratically. The visible effect is a ragged edge to the picture.

The waveforms in various parts of the circuit are shown in Figs. 2 and 3 for the line and frame time-bases respectively. These were all taken using the "Television Oscilloscope*." In the case of the frame time-base, most were taken using a 10-MΩ resistor as a probe to minimize the effect of the oscilloscope on the time-base. In conjunction with the capacitance of the cable, this acts as a filter and removes the small content of line pulses which appear on some of the waveforms. If such a filter is not used, several of the frame waveforms will not appear as traces with clean lines but rather as fuzzy outlines.

In the line time-base the oscilloscope was connected across R_{45}, R_{46} and R_{47}, so that its case was live to h.t. If this is not done, the small ripple on the h.t. line appears also on the trace to distort it. Since this makes the case of the oscilloscope live, care must be taken in handling it.

* "Television Oscilloscope", by W. Tusting, *Wireless World*, June and July 1952.

LIST OF PARTS

Resistors

R_1	2.2MΩ	½W	Erie
R_2	100kΩ	½W	Erie
R_3, R_{26}, R_{29}	10kΩ	½W	Erie
R_4	33kΩ	½W	Erie
R_5, R_8, R_{30}	22kΩ	½W	Erie
R_6	220kΩ	½W	Erie
R_7, R_{12}, R_{22}	47kΩ	½W	Erie
R_9	2.2kΩ	½W	Erie
R_{10}, R_{11}	22kΩ	1W	Erie
R_{13A}	50kΩ	potentiometer, wire-wound, linear, 5W	Reliance Type T.W./1
R_{13B}	39kΩ	1W	Erie
R_{14}, R_{17}, R_{27}, R_{28}	1MΩ	½W	Erie
R_{15}, R_{32}, R_{33}, R_{37}	470kΩ	½W	Erie
R_{16}	2MΩ	variable, linear	Reliance Type S.G./1
R_{18}, R_{19}, R_{39}, R_{40}	33Ω	½W	Erie
R_{20}	150Ω	½W	Erie
R_{21}	6.8kΩ	2W	Erie
R_{23}	250kΩ	variable, log-law	Reliance Type S.G./1
R_{24}	470Ω	½w	Erie
R_{25}, R_{35}, R_{36}	20kΩ	variable, wire-wound, linear, 5W	Reliance Type T.W./1
R_{31}	1kΩ	½W	Erie
R_{34}	8.2kΩ	½W	Erie
R_{38}	120Ω	2W	Erie
R_{41}	300Ω	variable, wire-wound, linear, 5W	Reliance Type T.W./1
R_{42}	330Ω	6W	Welwyn
R_{43}, R_{44} each 2 ×	470kΩ	1W	Erie

Capacitors

C_1, C_4, C_5, C_8, C_9, C_{11}, C_{13}	0.1μF, tubular paper, 350 V, Dubilier Type 460
C_2, C_6, C_{12}	8μF, electrolytic, 500 V, Dubilier Drilitic BR850
C_3, C_{16}	200pF, silvered mica, 350 V, Dubilier Type 635
C_7, C_{14}	0.05μF, tubular paper, 350 V, Dubilier Type 450
C_{10A}, C_{10B}, C_{19}	50μF, electrolytic, 50 V, Dubilier Drilitic BR505
C_{15}	20pF, ceramic, Dubilier Type CTD316
C_{17}	0.001μF, moulded mica, 350 V, Dubilier Type 635
C_{18}	0.01μF, tubular paper, 350 V, Dubilier Type 460
C_{20} 6 ×	120pF, silvered mica, 750 V, Dubilier Type 635
C_{21}	200pF, mica (see text), Dubilier Type 680
C_{22}	0.5μF, tubular paper, Dubilier Type 4706B
C_{23}, C_{24}, C_{25}, C_{26}	0.001μF, 10 kV, Dubilier Type 411

Valves

V_1, V_2, V_3, V_5, V_6	EF91 Mullard
V_4	EL42 Mullard
V_7	EL38 Mullard
D_1, D_2, D_3	Westinghouse 36 EHT60
D_4	Westinghouse 14 D134

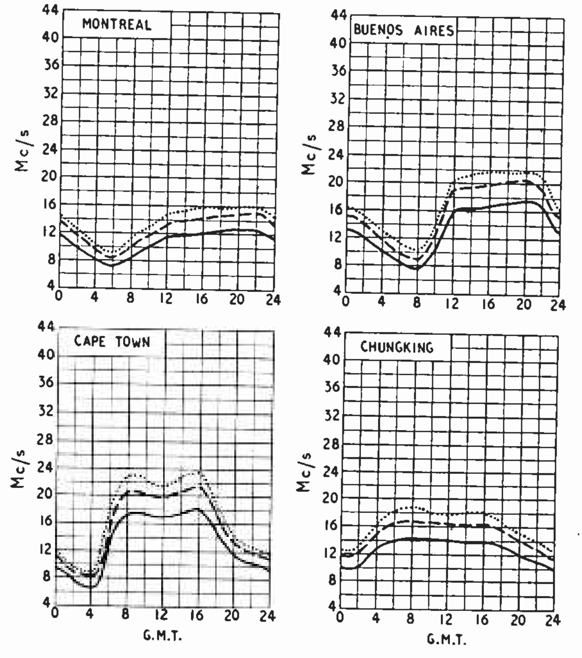
(to be concluded)

Short-wave Conditions

Predictions for June

THE full-line curves given here 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 June.

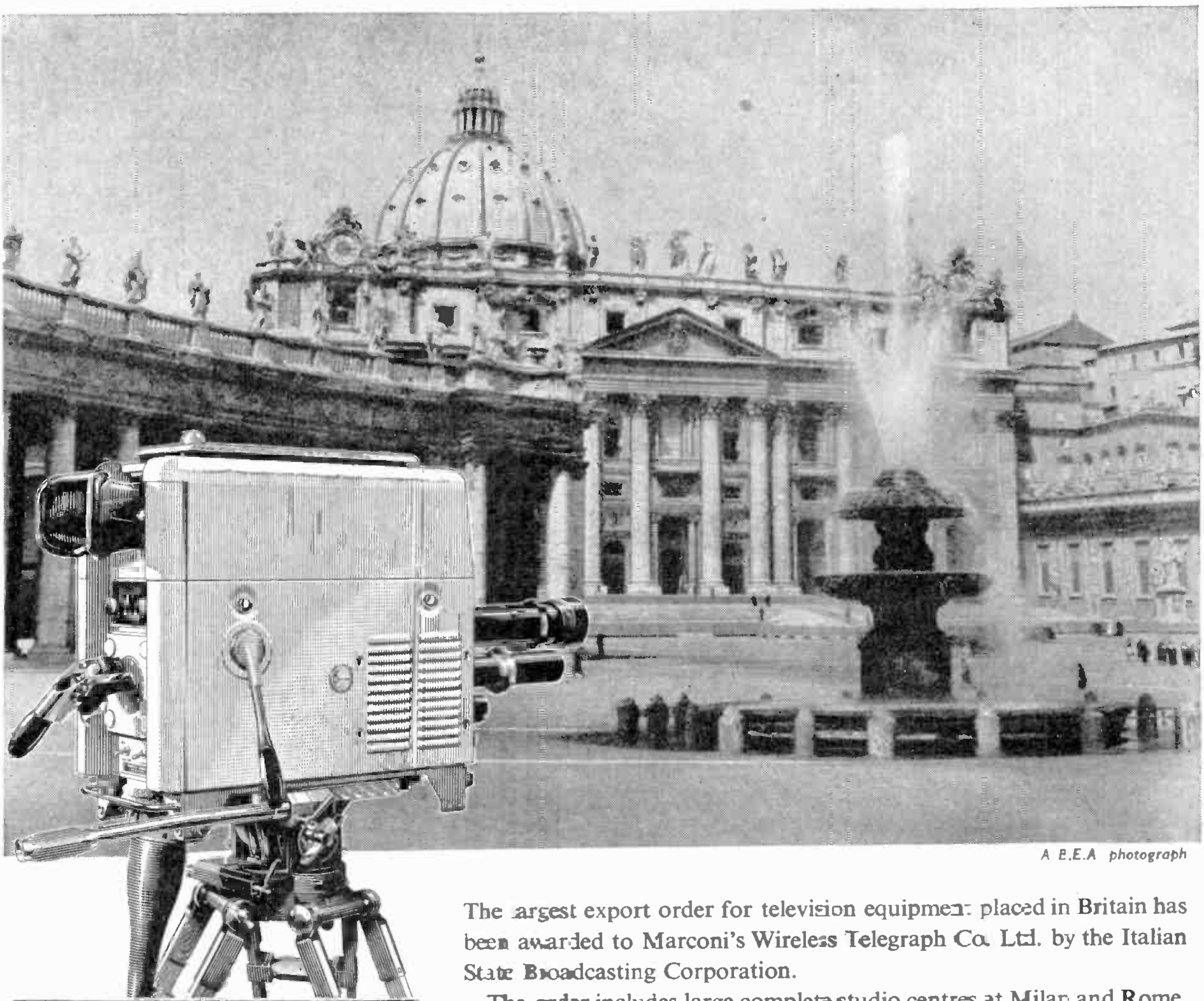
Broken-line curves give the highest frequencies that will sustain a partial service throughout the same period.



—— FREQUENCY BELOW WHICH COMMUNICATION SHOULD BE POSSIBLE ON ALL UNDISTURBED DAYS

– – – – PREDICTED AVERAGE MAXIMUM USABLE FREQUENCY

·········· FREQUENCY BELOW WHICH COMMUNICATION SHOULD BE POSSIBLE FOR 25% OF THE TOTAL TIME



Radio Waves

How the Magnetic and Electric Fields Support Each Other

By "CATHODE RAY"

DURING the war, when thousands of people had to be trained in the shortest possible time to look after radar equipment, it surprised everybody, I think, how in a few months any reasonably intelligent lad, starting right from scratch, seemed to be quite at home among unprecedentedly complicated circuitry. Some of them, not noticeably bright in other respects, could quite readily reproduce diagrams of such circuits from memory. We, who were called upon to do our spot of instructing, sometimes wondered what we could have been doing during our years of study! But when questions were asked that required the application of basic principles to a new situation some of the most outstanding memorizers failed the most dismally. It was not that they couldn't recite all the necessary principles from memory. The difficulty was—and is—first to know which to pull out of the bag, and secondly, how to use it. A, who relies entirely on memory and practical experience can go far astray when he comes up against something unfamiliar; B, who works things out from principles may be hopelessly slow at routine stuff but can find his own way over new ground.

Exactly what happens between radio sender and receiver doesn't concern most of us very deeply most of the time; we are taken up with what happens before and after, and may not have to dig out our basic principles often enough to prevent them from getting rusty. So a little practice here and now may be all to the good.

Two months ago, you may remember, I mentioned that radio waves—electromagnetic waves, to be precise—consist of equal electric and magnetic fields. People sometimes ask, "Which part produces the signal in the receiving aerial; the magnetic, the electric, or both?" If the receiving aerial were close enough to the source to be affected by *induction* fields, this would be quite a sensible question, because the induction fields are those parts of the total electric and magnetic fields that depend directly on the source, so it is possible for them to be mainly electric or mainly magnetic, depending on whether the source is energized mainly by voltage or current. That is why G. Bramslev was able to show (in the Nov. 1952 issue) how to use a frame aerial to discriminate against noise interference from sources producing mainly electric fields. When no clear distinction is made between induction fields, tied to their mother's apron strings, and radiation or wave-motion fields, making their own independent way through the world, it is not surprising that there are confused ideas about wave reception, such as a belief that an open-wire aerial responds to the electric part of a radiated wave and a frame aerial to the magnetic part, so that one can choose whichever one wants. Actually, asking which part of the wave causes the signal in either kind of aerial is rather like asking whether things blown over by the wind are affected by the movement or the pressure of the wind. Without movement there would be no one-way pressure, and without pressure there would be no movement. The two are inseparable, so you can please yourself which you say is the cause.

If you still feel puzzled about this, even after the difference between induction and radiation has been made clear, I am not surprised. It does seem contradictory. Fact One is that an open-wire aerial responds to an induction electric field and a frame aerial or coil to an induction magnetic field, but not vice versa. Fact Two is that there is no difference between induction and radiation fields themselves but only in the way they are organized. And yet one is asked to believe that with radiation fields the type of aerial cannot be used to distinguish between the electric and magnetic parts, and that this is not simply because the electric and magnetic fields happen to be present in equal proportions. The only possible explanation must lie in the difference in organization between induction and radiation fields.

That is quite so, but to see it one needs to fall back on first principles. And it is just as well to remember that these principles are not mere armchair theory but are the results of actual experiments. One of the greatest of all experimenters was Faraday. He it was who discovered how to generate electricity by magnetism. (The generation of magnetism by electricity had already been discovered.) He found there were two ways of generating an e.m.f. in a coil of wire. One was to push a magnet in or pull it out. He found the e.m.f. lasted only while the magnet was moving relative to the coil. Of course the same result was obtainable with a fixed magnet and moving coil. The principle of the thing was summed up by saying that whenever any part of a circuit is cut by the flux of a magnetic field the circuit receives an e.m.f. proportional to the rate of cutting. If you were to get a large magnet and a small piece of wire as in Fig. 1, and move the magnet at right angles to the wire (i.e., towards or away from you in (a), and to left or right in (b)) the magnetic field extending between the poles of the magnet would cut across the wire and generate in it an e.m.f. The rate of cutting, and hence the e.m.f., would obviously be proportional to (i) the strength of the field, or flux density, (ii) the speed of movement, and (iii) the length of the wire.

The other epoch-making experiment of Faraday was to generate an e.m.f. in a coil *without any movement*, by varying the strength of the magnet. He did this, of course, by using a coil of wire as the magnet, switching the current on and off. Again, the e.m.f. lasted only while the magnetism was varying. This result was generalized by saying that if the amount of magnetic flux linked with any circuit is varied the circuit will receive an e.m.f. proportional to the rate of variation.

On the first experiment is based the generation of nearly all the world's electricity supplies, and on the second the transformers needed to make those supplies economically available; so no wonder Faraday is the " patron saint " of electrical engineers.

As sometimes taught, the flux-cutting idea (Fig. 1) is given as the basic principle, and the flux-varying idea is brought into line with it by supposing that when a current is switched on the resulting flux springs out from it and cuts across any close-up circuits, and when it is switched off it returns inwards and cuts them again in the opposite direction. This mental picture is none too clear when it is called upon to explain the e.m.f. of *self*-inductance. How does the flux springing out from a wire cut that wire itself? And this is not the only dubious aspect of the flux-cutting idea. The " experiment " purporting to demonstrate it (Fig. 1) is quite phoney. Unlike those of Faraday, it is not an experiment that can be performed. To demonstrate the existence of the e.m.f. it is necessary to connect a voltmeter between the ends of the wire; then what about the voltmeter leads? If they are kept within the field as in Fig. 2(a) they too are cut by the flux so they receive an e.m.f. which (assuming the field is uniform) exactly counterbalances the e.m.f. in the wire and one is none the wiser. If the leads are taken horizontally as in Fig. 2(b) so that they are not cut, the e.m.f. now shown by the voltmeter can be explained equally well by the fact that moving the magnet in the direction of the arrow increases the flux linking the circuit. The absence of result in Fig. 2 can likewise be explained on the same basis; the assumption that the field is uniform means that moving the magnet does not alter the flux linked with the circuit. So both of Faraday's methods of inducing an e.m.f. can be visualized and calculated as flux-linkage variation, without any need to bring in the rather shaky and experimentally undemonstrable flux-cutting picture.

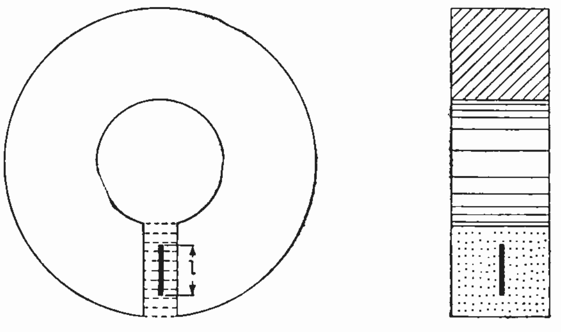


Fig. 1. The basic principle of how electricity is generated in a power station is often expressed something like this, by saying that if a magnetic field is moved across a length of circuit l an e.m.f. is generated in it, proportional to l and to the rate at which the field is moved across. Here the field is shown as due to a permanent magnet, moved towards or away in (a) and to right or left in (b), which is a cross-section of (a).

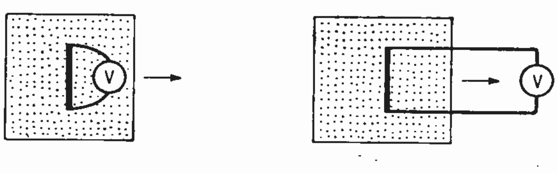


Fig. 2. When an attempt is made to verify Fig. 1, it is necessary to take account of the voltmeter leads. Moving the magnet causes no reading in (a); the arrangement shown in (b) is successful, but the action can at least equally well be explained as change of magnetic field passing through the whole circuit.

Example of Flux Linkage

Just to consolidate the matter, let us take a simple example; say the Fig. 2(b) situation, making the assumption that the flux density is uniform between the pole-pieces and zero elsewhere—no " edge effect." Wire, flux, and motion are all mutually at right angles. Field calculations are easiest if one uses the m.k.s. system of units, as most modern books do. The voltage generated is equal to the rate of flux cutting or linkage if that is in webers per second (1 weber = 10^8 " lines "). Suppose the flux density (B) is 1.2 webers per sq metre (12 kilogauss in the old units), the wire is 0.02 metre long, and the magnet is moved at 0.5 metre per sec. Then the cross-section area of flux passing through the circuit increases at the rate of $0.5 \times 0.02 = 0.01$ sq metre per sec, so the rate of flux linkage, and hence the induced voltage, is $0.01 \times 1.2 = 0.012$. If the process is pictured as flux cutting the original vertical wire, the figures are of course the same, but the result (0.012) must not be taken as the measurable voltage until one has made sure that no other parts of the circuit are being cut by any flux. Because of this the flux-linkage way of looking at it is both safer and (in less absurdly simple examples) may be easier.

So far we have supposed this moving magnetic field to be produced by a permanent magnet. But of course it could be an electromagnet. Fig. 3(a) shows a single-turn coil of wire carrying d.c. Its magnetic field is at right angles to the paper, and with an anti-clockwise current as shown it is towards us, as suggested by the dots. Next (b) imagine the loop to be whisked rapidly to the right. The effect of this is that paths such as those shown dotted experience an e.m.f. tending to drive current in the directions shown. But because no circuits are provided there, it is only a tendency. One can say that within the area covered by the loop at any instant there is an upward e.m.f.

Electric-Field Current

At this stage a little digression may be necessary to recall what happens when an e.m.f. is applied across a space. This is done in Fig. 4 by connecting a battery to a pair of parallel plates. The e.m.f. of the battery sets up a potential difference between the plates, which is another way of saying that there is an electric field between them, indicated conventionally by the lines in Fig. 4. This field is reckoned in volts per metre. But before it can exist the battery must have driven a current from the lower to the upper plate in order to charge it positively. (Actually what happens, of course, is that electrons are driven downwards on to the lower plate to charge it negatively, but that is just another way of saying the same thing.) To anybody who thinks in terms of circuits and current electricity rather than charges and static electricity, this charging current is something of an anomaly. How can a current flow in a circuit that is not complete? Maxwell, the genius who brought his mathematics to bear on Faraday's experimental results and predicted electromagnetic waves, argued that what happened in the space occupied by the field was equivalent to a current; it flowed only so long as the field strength was varying, so could not continue indefinitely in the same direction, and to distinguish it from conduction or circuit current he called it displacement current. It is like the limited movement in a fixed block of rubber while pressure is being increased across it. So we think of the temporary current that flows upward through the battery in Fig. 4 when it is connected as being continued back to the start by a downward displacement current in the space between the plates.

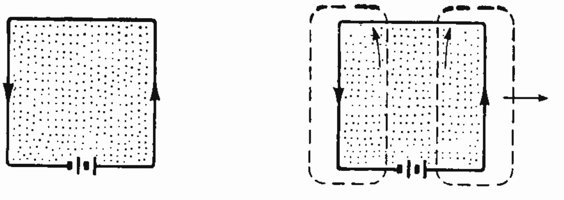
To fit this Fig. 4 picture into Fig. 3 it is necessary to imagine that the battery fills the whole of the space covered by the loop, because it is all occupied by upward e.m.f. So the downward displacement current must all flow outside the loop area. Finally, since the e.m.f. is not produced by a battery at all but by a moving magnetic field, the upward current too must be a displacement current. Since space at the top of the loop is positively charged, an upward displacement current must have just occurred in order to make it so; in fact, at the extreme right-hand side of the loop the space is actually in the process of becoming positive at the top, and so a displacement current must still be occurring here. *Note that it is in the same direction as the magnetizing current produced by the loop battery.* At the left-hand side the positive charge must disperse as the edge of the loop passes by, so here there is a downward displacement current—again in the same direction as the magnetizing current.

Now any current causes a magnetic field; no questions are asked as to whether it is a conduction current or a displacement current. So when the loop is moved there is no need to supply quite so much current from the battery; the difference is made good by the displacement current caused by the motion. The faster the loop is moved the greater the electric field developed by a given magnetic field and the greater the displacement current. If the loop were moved fast enough, could it be dispensed with altogether, the moving magnetic field being sustained entirely by displacement currents?

That is the question that Maxwell answered and expressed in the celebrated Maxwell equations. These don't mean a thing to anybody who is not rather unusually bright at mathematics, so I shall try to arrive at the answer by an easier route, even if it may not altogether satisfy the stricter mathematicians.

What we know already is that the electric field (denoted by ϵ) is equal to the voltage per metre p.d. set up by the movement of the magnetic field. (If an air capacitor with plates 1 mm apart is charged to 50V, the electric field in the space between is 50,000 V/m.) And we know that the voltage is equal to the rate at which the flux is changing in the space concerned. The flux (Φ) is equal to the flux density (B) multiplied by the area of its cross-section. And B is equal to the magnetic field strength (H) multiplied by the permeability (μ). And in m.k.s. units H is equal to the ampere-turns per metre of field length. We can greatly simplify the putting of all this together if we make our chunk of space a one-metre cube. The original magnetizing loop would appear in Fig. 3 as a one-metre square, but this would be an edge-on view of a turn made of strip one metre wide. Suppose that at the instant considered it exactly contains our stationary cube of space. And let the current round the loop be I amps. Then H is equal to I, and B (and therefore Φ in this case) is equal to μI. The rate at which Φ is changing in this space depends on the speed with which the loop is moved across the space. By the time it has been shifted one metre the whole of the flux Φ has been taken away, so if the speed is v metres per second the rate of change of Φ is $v\,\Phi$, and we know this is equal to ϵ. So the final upshot is

$$\epsilon = v\mu I$$



(a) (b)

Fig. 3. If a simple loop electromagnet as shown, producing a magnetic field pointing towards the reader, is moved to the right it causes an upward e.m.f.

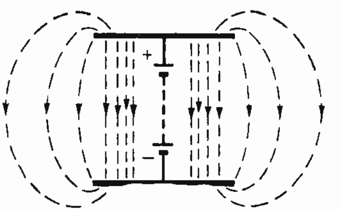


Fig. 4. In order to set up a potential difference between two plates it is first necessary for a temporary charging current to flow, and this is supposed to be continued as a displacement current along the directions of the electric field, shown here.

Doing Without the Loop

Now to render the magnetizing loop entirely unnecessary, I has to be the displacement current generated by the charging of the space. A current is the rate at which electric charges are being moved. If a charge amounting to one coulomb is transferred at a steady rate in one second the current is one amp. The amount needed to charge C farads to V volts is CV coulombs. Our chunk of space can be regarded as a capacitor with plates one metre in area spaced one metre apart. Its capacitance in m.k.s. units is equal to the permittivity (κ) of space. The movement of the magnetic field at v m/s causes it to be charged to ϵ volts v times per second, so the rate at which charging takes place (which is I) is $\kappa\epsilon v$ coulombs per second. So now we know that $I = \kappa\epsilon v$. But our previous result told us that $I = \epsilon/v\mu$. So putting these together we get

$$\kappa\epsilon v = \frac{\epsilon}{v\mu}$$

$$\therefore \kappa v = \frac{1}{v\mu}$$

$$\text{and } v^2 = \frac{1}{\mu\kappa}$$

$$\text{so } v = \frac{1}{\sqrt{\mu\kappa}}$$

For reasons that are too involved to explain in passing, the m.k.s. electrical units are based on the μ of empty space—air is practically the same—being equal to $4\pi/10^7$. Measured in the same units, κ is found to be almost exactly $1/(36\pi \times 10^9)$, so

$$v = \sqrt{\left(\frac{10^7}{4\pi} \times 36\pi \times 10^9\right)}$$
$$= \sqrt{(9 \times 10^{16}}$$
$$= 300{,}000{,}000 \text{ metres per second approximately*.}$$

That is the speed at which fields have to move through space in order to be self-supporting. This apparently formidable requirement is in fact quite easily met, for any change in the magnitude of any current or voltage anywhere starts the process and launches an electromagnetic wave. But as we have seen in recent issues, it is only when the originating circuit is large and the rate of change rapid that the resulting wave is likely to be substantial.

If we did the above calculation more thoroughly, using a chunk of *any* dimensions, these would cancel out, giving the same result. I suggest you try it, just to convince yourself. Maxwell, being the bright boy he was, arrived at it by strict mathematical processes, before anybody knew definitely that electromagnetic waves were possible. It was Hertz who came along later and proved Maxwell right by demonstrating such waves produced by electrical means.

In case anyone thinks I have been trying to pull a fast one by quietly forgetting about the current in the top and bottom of the magnetizing loop that was necessary to produce the magnetic field, I would hasten on to Fig. 5, which shows what happens when 1-metre "bricks" are put together as a start towards unrestricted open space. The currents in adjacent parts cancel out, so the dimensions of the bricks don't matter at all.

Another thing: the result does not depend on using m.k.s. units. Any system of units, recognized or unrecognized, will do, provided it *is* a system.

* The latest estimate is 299,792,000.

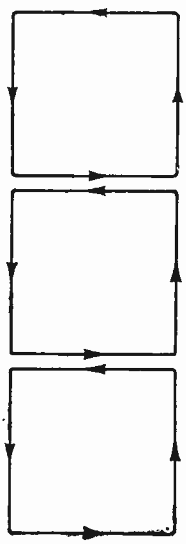
Procession of Fields

Before finally knocking away the visible scaffolding that has helped us to build a picture of electromagnetic radiation, let us multiply it a little as in Fig. 6, showing three links in a whole chain of loops all moving to the right, with currents alternately clockwise and anti-clock. The middle one, S, is just our old Fig. 3 friend, now escorted fore and aft by R and T. Between R and S the space which a moment ago, while R was passing, was positive below is becoming positive above, so an upward displacement current is necessary. Between S and T it must clearly be downward. Now accelerate the procession to the speed at which battery magnetization is unnecessary, and what remains is a sequence of moving fields, alternately positive and negative; each bunch of magnetic field pointing towards us being accompanied by an upward-pointing electric field, and followed by an away-pointing magnetic field accompanied by a downward electric field. Since there is now no apparatus to maintain either field, each relies entirely on the other for its existence. It is the perfect marriage; they cannot be parted even by death.

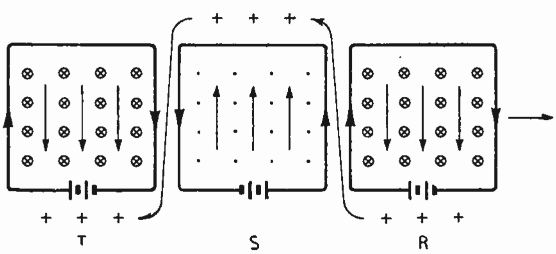
So there is really not very much point in arguing about which partner causes the signal in a receiving aerial. Radiation can only exist as a combination—an electromagnetic wave. The logical view is that the electric field is primarily responsible, because that is what the free electrons in the aerial respond to. But since the radiated electric field is generated by the magnetic field the same answer is obtained if one supposed the e.m.f. in the aerial to be generated by the magnetic field as in ordinary Faraday induction. In practice the strength of a radio wave is usually given in terms of its electric field, in microvolts per metre, because this gives the aerial e.m.f. directly.

Fig. 6, you remember, was a sample of what we imagined to be a long chain of "links." A pair of them, say S and R, makes up one complete wave, with positive and negative half-cycles. So wavelength is represented by twice the width of one link.

All the way through we have, for simplicity, been assuming that the fields are uniform over a whole link, loop, chunk, or brick. So Fig. 6 represents square waves. In practice one is more often concerned with sinusoidal patterns of field strength, and the calculations are usually made on that basis, which does not alter the main conclusions.



Left: Fig. 5. Showing how any number of current loops can be put together to form a larger one, because the currents along internal frontiers cancel out.



Below: Fig. 6. Elaboration of Fig. 3 to show a procession of magnetic fields on the move, with the resulting displacement currents that help to maintain the magnetic fields and therefore themselves.

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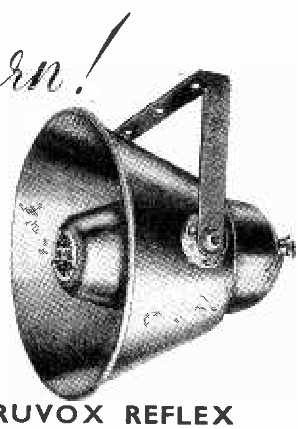

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Voltmeter Loading

Use of Potentiometer Method

IT is very well known that the measurement of voltage in high-resistance circuits is liable to be inaccurate because of the load imposed by the voltmeter. It is surprising, therefore, that more use is not made of a method which is described in all text-books of electricity—the potentiometer method.

A voltmeter requires some power to operate it and this power is normally supplied by the circuit under test. If this circuit is of high resistance it cannot supply the necessary power without a drop in voltage. In the potentiometer method, a separate source of power is used to operate the voltmeter and the circuit under test has to supply no power at all. It is, therefore, quite unaffected by the connection of the measuring circuit.

The arrangement is shown in Fig. 1, where M_1 is any ordinary voltmeter. The associated apparatus comprises a second meter M_2, which is preferably a centre-zero galvanometer, a potentiometer R and a battery V of voltage greater than that to be measured. The circuit under test is represented by a box with two terminals AB. The measuring circuit is connected to AB, R is adjusted so that M_2 indicates zero and the voltage is read from the voltmeter M_1.

If R is adjusted so that there is no current in M_2, then AB neither supplies current to nor draws current from the measuring circuit. The voltage between A and B is thus the same as if the measuring circuit were not connected. If there is no current in M_2 the voltage across M_2 must be zero and so the voltage between C and D must be the same as that between A and B. The voltmeter M_1, however, indicates the voltage between C and D; therefore, it gives a true indication of the voltage between A and B. The power for operating the voltmeter is drawn entirely from the battery V.

In practice, it is not very convenient to have to use a separate power supply in this way. In most radio apparatus, however, the voltages appearing at high-resistance points are derived by voltage-dropping from a common higher-voltage supply of relatively low resistance. Screen-grids, for example, are fed from the main h.t. line through dropping resistors or potential dividers. In most cases, therefore, the main h.t. line of the apparatus can be used for the voltmeter supply and the battery of Fig. 1 becomes unnecessary.

The basic circuit of Fig. 1 can be simplified by the omission of the battery but in other ways it requires some elaboration. It is necessary to have something to protect the meter M_1 in case R is a long way from the proper adjustment when the circuit is connected. Let the voltage under test be V_{AB} with a source resistance R_{AB}. If the slider of R is at the bottom, the current in M_2 will be $V_{AB}/(R_{AB} + R_m)$, while if it is at the top it will be $(V_{AB} - V)/(R_{AB} + R_m)$, where R_m is the resistance of the meter.

It is necessary to make R_m large enough so that under these extreme conditions the current will not exceed the full-scale value of M_2. The worst conditions are when V_{AB} is much less than V or nearly equal to V and, for complete safety under all conditions, it is desirable to have V/R_m no greater than the full-scale current of M_2. In effect, this means that M_2 must be a voltmeter having V within its range.

The resistance of M_2 will then be high and this will make the meter an insensitive indicator of the balance condition and it will be difficult to determine the proper setting of R. To overcome this, the resistance can be short-circuited by a switch as balance is approached.

A second defect of the arrangement of Fig. 1 is that a potentiometer of ordinary quality does not give a fine enough control of voltage, particularly at low-voltage settings. It is often desirable to supplement it by a variable resistance. The circuit then takes the form shown in Fig. 2. R_1 and R_2 should be of about the same value and 20 kΩ is suitable in most cases. With a 300-V h.t. supply they will draw up to 15 mA and the power will be up to 4.5 W, so components of at least 6-W rating should be used. If M_2 is a centre-zero instrument reading 1 mA f.s.d., R_m should be 300 kΩ to avoid any possibility of overloading it.

In use, terminals 1 and 3 are connected to positive and negative h.t. of the apparatus under test and 2 is joined to the point at which it is desired to measure the voltage. With R_1 about mid-way on its travel, R_2 is adjusted for zero reading on M_2 (if this comes at the top of R_2, R_1 is reduced). Then S_1 is closed and R_2 (and R_1 if necessary) is re-adjusted more precisely.

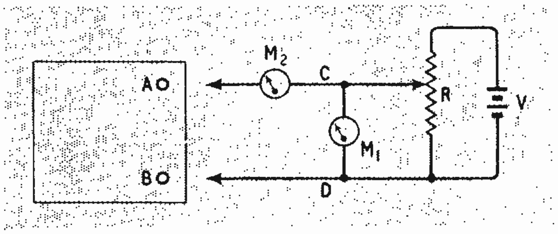
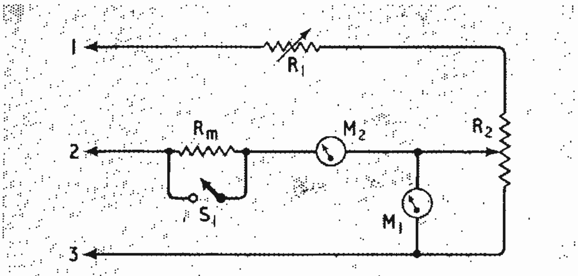


Fig. 1. Basic potentiometer circuit for voltage measurement.

Fig. 2. Practical circuit. M_2 is a centre-zero milliammeter.



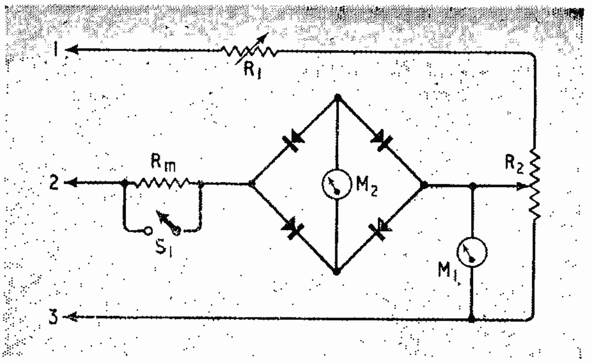


Fig. 3. Circuit for use with a left-hand zero meter for M_2. The metal rectifiers ensure that the meter deflects one way only irrespective of the direction of the current.

When a centre-zero meter is not available, the ordinary left-hand zero type can be used in conjunction with a bridge-type metal rectifier of the kind used in a.c. instruments, as shown in Fig. 3. This makes the meter reading independent of polarity and so the adjustment for zero current becomes one for minimum deflection of the pointer. The sensitivity obtainable is not quite so great because the resistance of the rectifier elements increases as the balance point is approached, but the adjustment of R is easier to carry out for a minimum reading than for zero.

It is, of course, possible to elaborate the scheme. By introducing switching, for instance, one meter can be used for both purposes. The voltmeter M_1, for instance, is only a milliammeter with series resistors. The meter itself can, therefore, be switched to do duty for M_2 if its voltage-range resistors are left in place to keep the proper load on R_2.

NEW BOOKS

Television Receiver Design : Monograph 1 ; I.F. Stages. By A. G. W. Uitjens. Pp. 177 + xii ; Figs. 123. Philips Technical Library : distributors ; Cleaver Hume Press, Ltd., 42a, South Audley St., London, W.1. Price 21s.

THE Philips organization (Holland) have already published English translations of a series of books on broadcast receivers by members of their staff, and they are now embarking on a similar series on television receivers. This, the first, deals with the i.f. stages ; the translation is, on the whole quite satisfactory ; printer's errors are few and, except in one instance, of minor importance. At the end is a list of symbols, some of which will be unfamiliar to the English reader. It is a pity that the opportunity was not taken to bring all the symbols into line with English usage, as this would greatly enhance the value of the book to a student reader. There are seven chapters on single and coupled tuned i.f. circuits with staggered tuning ; gain-bandwidth, distortion, noise and valve inter-electrode feedback problems are thoroughly explored. The text is illustrated by numerical examples and the last chapter details a particular design of staggered tuning with five single circuits as well as indicates the response to a modulation envelope step function ; a circuit diagram of the complete amplifier would have been helpful. The effect of trap circuits protecting from adjacent channels is considered, and reasons are given for the choice of the circuit to which they are connected. To preserve continuity proofs of many expressions used in the text are relegated to appendices. In Appendix 1, the attenuation and phrase responses of a single tuned circuit are derived, and input, output and transfer impedances, and admittance locus diagrams are developed for dissimilar as well as similar tuned circuits coupled by mutual inductance. Constant reference must be made to the list of symbols if the derivations are to be followed. In section 1*g* it is not immediately clear that the primary is the coupling circuit and the secondary an absorber circuit when discussing trap circuits in terms of tuned coupled circuits. A diagram including values, such as Fig. 74 with suitable captions, would have made this clear. Appendix 2 develops the expression for determining the response of staggered tuned circuits as used in Chapter 2 where the principle of "flat" staggered tuning is clearly set out.

In television receiver design it is important to know how the pulse shapes of the input signal are modified in their passage through the i.f. stages, and Appendix 3 shows how the modifications can be determined from the attenuation and phase response characteristics. A misprint makes Appendix 4 on noise factor calculations difficult to follow ; Fig. 31 should read Fig. 56. Appendix 5 develops expressions used in Chapter 6, where feedback effects due to valves are considered. Table 1 provides information on the characteristics (gain-bandwidth, etc.) of Philips valves suitable for use in wideband amplifier stages. The remaining three tables are concerned with factors of importance in staggered tuned circuits. There is no index.

The inexperienced designer will find much of value in this book but the expert will discover little that he does not already know.
K. R. S.

Sound Reproduction (Third Edition) by G. A. Briggs. Pp. 368; Figs. 315. Wharfedale Wireless Works, Bradford Road, Idle, Bradford, Yorks. Price 17s 6d.

WRITTEN professedly in non-technical language and addressed primarily to the layman, this book contains, nevertheless, much material of interest to the knowledgeable enthusiast, and the terms non-technical and semi-technical, often used by the author, should be liberally interpreted. The field covered is wide—literally *all* aspects of sound reproduction not dealt with in greater detail in the author's other books on "Loudspeakers" and "Amplifiers"—and this third edition has been brought up to date by extensive revision of the original text and by the addition of eight new chapters.

Mr. Briggs has been fortunate in his collaborators and the chapter on vented (reflex) cabinets by R. E. Cooke is probably the best exposition of the underlying principles so far published. This is backed by tables giving specific recommendations for cabinet dimensions to suit typical sizes of loudspeaker and cone resonances. R. L. West and S. Kelly contribute new material on the design of pickups, and the practical aspects of successful magnetic tape recording are ably dealt with by C. H. Banks and L. J. Bradley. The chapter on cross-over networks is detailed and contains much useful coil-winding data, together with some concrete facts about phase shifts near the cross-over frequency—hitherto a somewhat nebulous bogy.

Mr. Briggs is an indefatigable experimenter and he has photographed countless cathode-ray oscillograms to verify the axiomatic as well as to illuminate the controversial in his search for better quality of reproduction. His conclusions are generally sound, but occasionally hasty as when he states (p. 37) that there is no "vibration" at the mouth of a quarter-wave pipe. A "velocity" instead of a "pressure" microphone would have given quite a different picture. There is also some confusion of thought on the role of density, Young's modulus and viscosity *sic* of materials involved in the production and transmission of sounds. Weight rather than density (p. 102) is the criterion for confining low-frequency sounds, and a high Young's modulus is not a necessity for producing high frequencies as his "odd man out" example of hand clapping (p. 183) seems to prove.

Whether one is learning from or disagreeing with the author—and no one interested in sound reproduction can fail to do both—there is little fear of falling asleep while reading this book.
F. L. D.

Proposed Television Stations

Plans for British Two-programme Service

ON July 1st the Stockholm Plans for broadcasting in bands 41-68, 87.5-100 and 174-216 Mc/s, which were signed on June 30th last year, officially come into force. So far as this country (which was among the 21 signatories) is concerned, the signature is effective only for Band I. The British delegation would not commit this country to the plans for Bands II and III until it had been finally decided by the Government whether a.m. or f.m. was to be used for the sound service in Band II and also precisely how Band III was to be used. The Atlantic City Convention (1947), which allocated frequencies *en bloc* to the various services, contains a footnote permitting the U.K. to use Band III for other than broadcasting; actually for point-to-point communication (174-200 Mc/s) and air navigational aids (200-216 Mc/s).

Provision is made in the Stockholm Plans for 40 television stations in this country—12 in Band I (including the existing and projected 10 stations) and 28 in Band III. In view of the recent statement by Sir Ian Jacob, director-general of the B.B.C., that the Corporation hopes to erect 10 low-power stations when the present scheme is completed, we give below a list of the 30 additional British stations provided for in the Stockholm Plans.

It must, of course, be pointed out that this list, which provides for a dual service for the whole country, was drawn up before any decision had been reached regarding sponsored television.

Vision (Mc/s)	Sound (Mc/s)	Station	E.R.P.* (kW)		Polarization
			Vision	Sound	
BAND I					
61.75	58.25	Isle of Man	25	6	H
		Channel Islands	5	1.25	H
BAND III					
179.75	176.25	Channel Islands	5	1.25	V
		London	200	50	V
		Pontop Pike	50	12	H
184.75	181.25	Aberdeen	50	12	H
		Holme Moss	200	50	V
		South Devon	50	12	H
189.75	186.25	Kirk o' Shotts	200	50	V
		Norfolk	50	12	V
		North Wales	50	12	H
194.75	191.25	Northern Ireland	50	12	H
		South East Kent	50	12	V
		Sutton Coldfield	200	50	V
		West Cornwall	50	12	V
199.75	196.25	Cumberland	50	12	H
		Wenvoe	200	50	V
204.75	201.25	Isle of Man	50	12	V
		Isle of Wight	50	12	V
		Londonderry	50	12	H
		North Scotland	50	12	V
		West Wales	50	12	H
209.75	206.25	Cumberland	50	12	H
		South East Kent	5	1.25	V
		West Wales	50	12	H
214.75	211.25	Londonderry	50	12	H
		Norfolk	50	12	V
		North Scotland	50	12	H
		North Wales	50	12	H
		West Cornwall	50	12	V

* Effective radiated power. H, Horizontal. V, Vertical.

RANDOM RADIATIONS

By "DIALLIST"

The Components Show

THAT SUCH NUMBERS of visitors should have made special journeys to the Components Show from twenty-one countries is an outsize feather in the cap of the R.E.C.M.F. This year there were more of them than ever. How important the exhibition has become in the eyes of the world may be gathered from the fact that not a few technical journals in other countries didn't just send reporters: their editors came themselves. Two whom I was delighted to meet (and who expressed unbounded admiration for what they had seen) were the editor of *Audio Engineering* from America and the editor of *Toute la Radio* from France. There were buyers, manufacturers, journalists and others from all over the Empire, and from many countries in Western Europe, Asia, America and Africa. It is indeed a tribute to British components that so many people should find it well worth while to make long journeys to attend this small, private, three-day exhibition. The R.E.C.M.F. has been wise in adopting and adhering to the world's strictest and most rigid standards in materials, design and workmanship. Quality pays—and goes on paying.

Striving for Inefficiency

SO POWERFUL are the a.m. and f.m. signals that I receive from the 20-kW Wrotham transmitter at a range of 50 miles with a pukka dipole mounted on a chimney stack, that I've been trying out aerials of lower and lower electrical efficiency with a view to discovering how far one can go before any marked falling off occurs. The arrangement I'm using at the moment cost 1s 8d, including the feeder. It consists of four yards of PVC-covered flex, the last $2\frac{1}{2}$ft of which were untwisted and straightened out, the single wires being stapled to right and left along a picture rail 8ft above the floor of a ground-floor room. Signal strength is still so ample that I shall have to work out something a good deal less effective before the answer is found. Metre-wave broadcasting when it comes (and may that be soon!) looks like having very great advantages over medium- and long-wave transmission. Among these, if f.m. is selected, are: (1) coverage of the same service area with about a quarter of the transmitter output power; (2) excellent reception (except in fringe areas) with the simplest and cheapest of indoor aerials; (3) far greater freedom from background hiss and impulsive interference; and (4) much better quality.

A Nice Point

SETTLE A COUPLE of wireless enthusiasts into comfortable arm-chairs of an evening and it won't be long before they start an argument on one of the finer points of their pet subject. Man has probably been an argumentative animal ever since he found out how to use speech to convey his thoughts and ideas to others. Our discussions and debates to-day carry on his age-old attempt to arrive at the truth about this or that. On a recent chilly evening a friend and I got on to the subject of valves as we basked in the warmth of a welcome fire. He's a bit of an authority on matters wireless; but I had to take him up when he described the thermionic valve as basically a voltage amplifier. His thesis was that voltage changes applied to the grid give rise to similar but much larger changes at the anode when a load is provided. By choosing the kind of anode load suitable for the work in hand you can pass these voltages on to another valve; or, you can use them as e.m.f.'s to drive current through a power-operated device such as a loudspeaker. I hold that the valve is essentially a power amplifier. There must be some resistance in the grid circuit and you can't get away from the fact that $V^2/R = W$, however small the figures may be. An amplified copy of these small applied powers appears in the anode circuit and you can use it as suits your purpose by selecting the right kind of anode load. I firmly believe that that is the best way of picturing the working of an amplifying valve. What are your views?

Room for Improvement

SORRY THOUGH I AM to have to say it, there cannot be much doubt that too many of the h.t. batteries available nowadays are pretty poor things. I am thinking particularly of those made up of $\frac{3}{4}$in × $2\frac{1}{8}$in cells, for they are by far the most widely used; but my criticisms apply equally to those with larger and smaller cells. If you care to work it out from the electro-chemical equivalent of zinc, you'll find that a $\frac{3}{4}$in × $2\frac{1}{8}$in can, weighing about 12 grams, has, in theory, a possible current output of 10Ah. Of course, you cannot expect to get anything like that from it since the cell is usually discarded when the e.m.f. has fallen from 1.5V to 0.9V. Still, with a load of 8-10 mA you should justifiably hope for a good bit more than the 0.7Ah to 1.1Ah that is all that I've been able to obtain of late from h.t. batteries with cells of this size. Again and again the overall e.m.f. of a battery has become unsteady after far too short a period of intermittent use. Once that happens, the set becomes increasingly noisy for an hour or two, and then packs up altogether. Test the battery with a high-resistance voltmeter and you'll find only tiny fractions of their stated e.m.f.s between certain tappings—usually near the middle. I have conducted post-mortems on scores of such batteries and have found in each case one or more perforated cells. Cell-perforation after a short period of intermittent use under a moderate load is something which, in my opinion, should not occur in a well-designed and well-made dry battery.

Full Speed Ahead

Towards the end of March an American friend asked me in one of his letters whether the imminence of the Coronation was producing record sales of television receivers. I replied that sales weren't too bad, except in Scotland, where comparatively few sets were being sold. "Possibly," I added, "the hard-headed Scots are holding their hands in the hope that the Budget will bring a reduction in purchase tax. If so, they are likely to be disappointed." My prediction could not have been more erroneous and I'm very glad of that. The reduced tax will mean bigger sales everywhere and, therefore, more money for research and development. It isn't always realized that television has had a hard battle to fight in this country. Our television service, the first in the world, was just getting nicely into its stride when the outbreak of war closed it down in the autumn of 1939. The TV research men were mobilized as the "back-room boys" of radar and had, so to speak, to beat their viewing screens into p.p.i. displays. Then when the war was over shortages of men, money and materials prevented the rapid development of our national television system. The heavy purchase tax imposed on receiving sets led inevitably to restricted sales and meant that with us television had to amble, instead of galloping, into its rightful position as the best of all sources of domestic entertainment. With the lowering of the tax, this Coronation year may well see a boom in television comparable with that which occurred in the early nineteen-twenties in "sound" radio.

UNBIASED | By FREE GRID

Forestalling the Future?

WHEN our descendants celebrate the Queen's Golden Jubilee forty-nine years hence, the newspapers will doubtless publish many articles dealing with various aspects of life in England during the early years of her reign. Our descendants are bound to be struck forcibly by the amazingly primitive and comfortless

Primitive and comfortless.

condition in which we were content to live having regard to the degree of scientific knowledge attained.

I think that one of the things at which the people of the year 2002 will marvel most will be that we early Elizabethans of 1952 could make an atom bomb but failed to use the resources of radio to enable us to maintain communications with the rest of the world when journeying by land. The provision of radio-telephonic facilities on trains and other public vehicles, although technically possible is, I suppose, banned by bureaucrats. This is, however, equally true of private cars, for the P.M.G. has never bothered to equip each telephone exchange with v.h.f. radio apparatus so that car owners, who installed the necessary equipment, could be linked with the national telephone system while travelling.

It is, however, a strange thing that if you own a boat and take your pleasure in it anywhere in the Thames Estuary the P.M.G. *does* provide a specially equipped telephone exchange for you so that you are as much "on the phone" as if you were at home. Recently I was visiting a friend who, like others of his kind, enjoys himself by spending his weekends on a small but well-equipped sailing craft.

I congratulated him on being "on the phone" in this special manner and said I wondered that he and others like him were not tempted, when temporarily abandoning ship on Monday mornings, to transfer the radio gear to their cars.

No reply was made to my observation but I did receive from my friend rather a queer look which might have been meant for silent reproof at my harbouring such subversive ideas; on the contrary, it might have been meant for withering contempt at my lack of sophistication. I just don't know. I merely record the facts and leave you to draw your own conclusions.

Silent TV

I WAS greatly interested in "Diallist's" prediction in the May issue that sets of the future may be provided with a three-position switch: sound and vision; vision only; sound only. But I certainly do not agree with him that more often than not the switch will be turned to the "sound-only" position. On the contrary, I think that if such a switch be provided it will almost invariably be turned to "vision only," and eventually the B.B.C. will radiate only silent TV.

I am led to this conclusion by the fact that owing to the development of a fault (which I have not yet found time to trace) in the "sound" side of my television set I have lately been looking at silent TV. As a result I have become quite expert at lip reading. I can, in fact, follow the dialogue by this means far more easily than I could when I had to rely on my ears, as the sound was so often rendered unintelligible by the ceaseless chatter of Mrs. Free Grid and her fellow females discussing the shortcomings of their respective husbands.

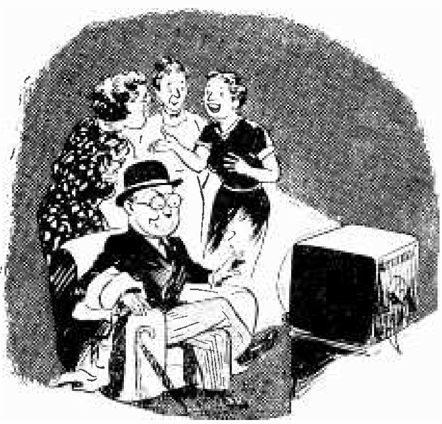
Even when I have the house to myself the peace and enjoyment of watching this silent TV has to be experienced to be believed. It does mean, of course, that I have to give the programme full concentration if it is to be intelligible, but this is as it should be. I have no more patience with people who use sound broadcasting as a sort of soporific background to their other activities than I have with those who go to the cinema and divide their attention between the screen and their own amateurish imitations of the amatory activities displayed on it. In common fairness, however, I must add that there is some excuse for their use of the cinema as an osculatorium as the proprietors fail to provide what used to be known in the U.S.A. as "necking niches" for those who don't want to see the film.

Inter-departmental Quiz

ANYTHING that smacks of the Totalitarian Police State is anathema to me. I must, therefore, register a very strong protest at the P.M.G.'s attempt to get the myrmidons of the Ministry of Transport to act as his Gestapo.

The current form which we all have to fill up when we want to renew our car licence asks bluntly "Is the vehicle fitted with a radio set?" If the answer is "Yes" we have to answer a further question which asks us if the set is separately licensed. These questions are, in my opinion, wholly irrelevant to the licensing of a car.

I presume that if the wretched motorist answers "No" to the question which asks him if the set is licensed, the information will be passed on to the P.M.G. Supposing the motorist declines to answer this question on the grounds that no man is compelled to answer a question which might incriminate him, I wonder if the authorities would refuse to issue him a Road Fund licence? I wonder, too, whether the police have instructions and the necessary authority to ask about the licensing of any set they may see



Decibelless dialogue.

installed in the car when taking particulars for some misdemeanour?

This sort of inter-departmental quiz is probably reciprocal and there is a danger that before long, when buying a radio licence at the local Post Office we may be asked if we have a clean driving licence. When applying for a marriage licence the bridegroom may, one day, be asked offensive questions about his income—at present the prerogative of the intended bride's father.