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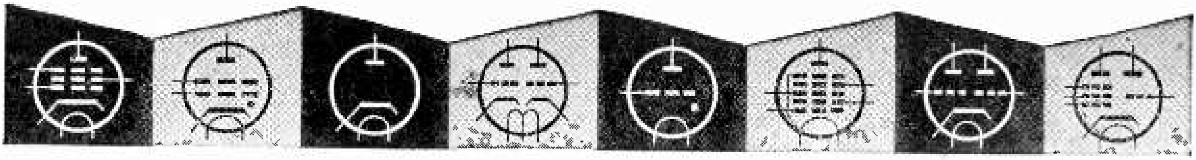

VALVES, TUBES & CIRCUITS

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Quite recently audio-frequency amplification has assumed still greater importance, both by reason of comparatively new applications and on account of greatly extended use of amplifier equipment for all applications. The rapidly increasing use of 16mm. sound film equipment in the domestic, educational and advertising fields; the growing popularity of tape recording; the high quality sound accompaniment transmitted by the B.B.C. Television Service—these are but a few of the factors in the increased demand for valves especially designed for audio amplification and in the need for modification or extension of the existing range of valves.

In satisfying these requirements an opportunity is presented for incorporating in each type all relevant improvements which have been developed over a period of time; for planning ahead so that the new range will also meet foreseeable requirements for some time to come; and for adopting in each case the latest manufacturing techniques, including the use of the now preferred base—the Noval (B9A) nine-pin base.

The new range of Mullard valves for audio amplifiers comprises the following types:—

EF86—pentode pre-amplifier, incorporating all the improvements with respect to low microphony, low noise and low hum level associated with the EF37A and EF40 which it now replaces.

ECC81 }
ECC82 } double-triode voltage amplifiers for such applications as dual input circuits, phase splitters, equalisation circuits etc. The range offers a choice of impedance to suit particular circuits; each triode section has an independent cathode.
ECC83 }

EL84—output pentode rated for 12W anode dissipation. A single valve gives an output of 4 to 5 watts into the speaker load and 16W can be obtained from a pair of EL84's operated in Class AB push-pull.

EZ80—full-wave power rectifier having a maximum output of 90mA.

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Wireless World

OCTOBER 1953 VOL. 59 No. 10

Domestic Radio, 1953

STEADY, though perhaps not spectacular, progress in all branches of domestic radio is recorded in our survey, printed in this issue, of current trends in design. As was expected, the greatest technical interest at the 20th National Radio Exhibition was concentrated on television receivers. Here it will be clear from our report that nothing approaching a standardized set with stereotyped circuitry has yet emerged. True, most receivers have a great deal in common, but there are endless variations in matters of detail—and in quite important details at that.

At this stage of development few would wish to see greater uniformity, though the wide diversity of size in cathode-ray tubes in popular demand must be an embarrassment to the manufacturers of those vital components. Up to the present there is no sign that fear of high replacement cost is curbing the public liking for still bigger tubes. The introduction of a tube reconditioning service is of economic rather than technical importance, but it may have a significant effect on the viewer when he comes to choose the tube size of his receiver.

Growing public interest in sound reproduction was well reflected at the Show. The magnetic tape recorder has, in a very few years, established itself firmly as a tool for the more serious uses and is well on the way to becoming established as a piece of domestic equipment for purposes of entertainment. There is, of course, still no sign that the tape will rival the disc record for home reproduction, and the makers of appliances for discs have ingeniously overcome the complications brought about by the recent introduction of varying speeds of rotation.

Sound receivers, though remaining the backbone of the broadcast receiving industry, have not greatly changed. Most of the developments are concerned with production.

Frequency Allocation Secrecy

DISCUSSIONS over frequencies for alternative television services have brought into the limelight one of the worst features of our system of allocating radio channels. Everything is done behind closed doors, and, as a rule, those concerned with one branch of communications have little idea of what has been done in another; still less do they know what is proposed to be done. Rational planning ahead is thus impossible. All this tends to incline our sympathies towards the system prevailing in America, where the deliberations of the Federal Communications Commission are conducted under the fiercest light of publicity.

The convenient word "security" is often invoked, though without proper justification, as an excuse for holding back publication of information on frequencies. A case in point is touched upon in a letter in our correspondence columns. The operating frequency of the air-sea rescue device there referred to was at first officially withheld. No "security" could have been involved, and we can only think this reticence was due to the fact that the frequency chosen for this new device fell within the debatable ground of television Band 3.

Television Interference Suppression

A CORRESPONDENT in the U.S.A., whose letter is printed on another page in this issue, seems to paint an over-rosy picture of the state of the ether in his country. The statement that ignition interference is unknown there is contradicted by reference to the American literature, where mentions of it are not hard to find.

Of course, the American system of negative modulation in television tends to reduce the annoyance value of ignition interference. And, although the American car owner may take no precautions against the radiation of television interference, is it not a fact that the use of car radio is widespread, and so most vehicles are effectively suppressed?

We cannot agree with our correspondent's implication that the remedy is in the hands of the television receiver designer. Most British receivers have built-in suppression, but there is a point beyond which it is uneconomic, undesirable and indeed impossible to go in this direction.

This Year's Trend in Television Receiver Design—and Some Highlights

In the following pages the technical staff of *Wireless World* report on tendencies in design in those branches of radio best represented at the National Radio Exhibition. This year technical interest at the Show was dominated by television. A survey follows of aviation radio equipment shown at the Farnborough Exhibition.

ALTHOUGH there is, as yet, no real uniformity among the television receivers produced by the various British manufacturers, the sets have a great deal in common and the variations are much more in matters of detail than in basic form. The straight t.r.f. set is now very rare, having fallen out of favour because of the difficulty of making it suitable for the reception of more than one signal channel.

To-day, the superheterodyne is supreme and the typical television receiver has one signal-frequency amplifier, a frequency changer, two vision i.f. stages and one or two sound-channel i.f. stages. Diode detectors and diode noise limiters are used in both channels, there is a single pentode video stage feeding directly to the cathode of the c.r. tube and one pentode develops the power needed for operating the loudspeaker. The sync separator usually has two valves—a pentode to remove the picture content and a diode to separate the frame from the line pulses. Both line and frame time-bases commonly have two valves each, apart from the efficiency diode in the line circuit. The e.h.t. is taken from the line-flyback pulse, using a valve rectifier, and the low-voltage h.t. supply from the mains, using a valve or metal rectifier in a half-wave circuit.

Within this broad framework there is endless variation of detail but certain particular forms of circuit do find greater popularity than others. The two main divisions into which nearly all sets fall are formed by the power supply. One group has series valve heaters and no form of mains-supply transformer; sets in this group are true a.c./d.c. types and will function on either supply. Sets in the other group may, or may not, have series heaters, but they have mains transformers. There are often auto-transformers for the h.t. supply and a main chain of heaters but with separate windings for one or two heaters. The technique is largely that of the a.c./d.c. sets, but this group is for a.c. only. In the true a.c./d.c. types, the h.t. supply is usually limited to 190 V, but in the second group the auto-transformer permits a higher voltage to be obtained and a 250-V line is not unusual.

An example of the a.c.-only set is the Ultra V814, shown in Fig. 1. Most of the valves are grouped in two series chains, one being fed across BF and the other across DF. The efficiency diode has its heater directly across CD and a thyratron is fed from a tapping EF. The c.r. tube has a separate winding for its heater. A, B and C form the taps for the mains-voltage adjustment and the h.t. rectifier is fed from the highest-voltage point A.

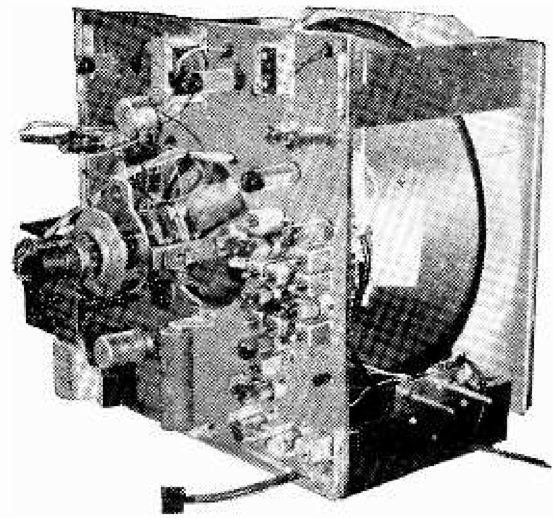
The advantage of this arrangement is not only the higher h.t. voltage obtainable. In addition, no special precautions have to be taken in the heater circuit. In the a.c./d.c. set, the heater of the c.r. tube must necessarily be in series with the valve heaters and its characteristics are by no means the same. In order to safeguard it during the warming-up period, it is necessary to have some current-control device in circuit. This often takes the form of a thermistor in series with the chain of heaters. In the G.E.C. BT5147, however, a barretter is used as well. The barretter was quite common in the early days of a.c./d.c. sets but fell into disuse and its revival in television is quite interesting.

With the low h.t. voltages available, especially in a.c./d.c. types, little voltage drop in the smoothing circuits can be allowed. A single choke of rather low inductance is usual with very large values of capacitance. The reservoir capacitance may be 100 F andμ the smoothing capacitance 200 μF. On a d.c. supply, the voltage at the output of the rectifier is lower than on an a.c. supply of the same voltage. The rectifier, however, is no longer necessary. Arrangements are sometimes made, therefore, so that it can be short-circuited on d.c. supplies.

A result of a.c./d.c. technique is that the chassis is in direct connection with the supply mains. In addition to the usual precautions against accidental contact with it, particular attention must be paid to the aerial circuit to avoid any possibility of the aerial, or its feeder, becoming live. Capacitors in both feeder leads are sometimes used; in other cases, there is a capacitor in the earthy lead only and the input coupling transformer is relied upon for isolation. There is a trend towards fitting an earth terminal so that the outer of the coaxial cable can be joined directly to local earth.

The use of one r.f. stage before the frequency changer is general and tuned couplings are employed between the two and between the aerial feeder and the r.f. valve. The number of tuned circuits, however, varies from two to four. The Philips TG1437U is an example of the use of four circuits and the basic arrangement is shown in Fig. 2. The screened twin feeder passes the signal to the coupling coil L_1 through the RC network, the purpose of which is to give an earthy centre point to the circuit, enable the aerial and feeder to be in direct connection with the local earth and to keep them isolated from the supply mains. An attenuator (not shown) can be included.

The coils of the input coupled pair are L_2 and L_3 and, in the intervalve circuit, the coupled pair is formed



Chassis of English Electric set with metal-cone c.r. tube.

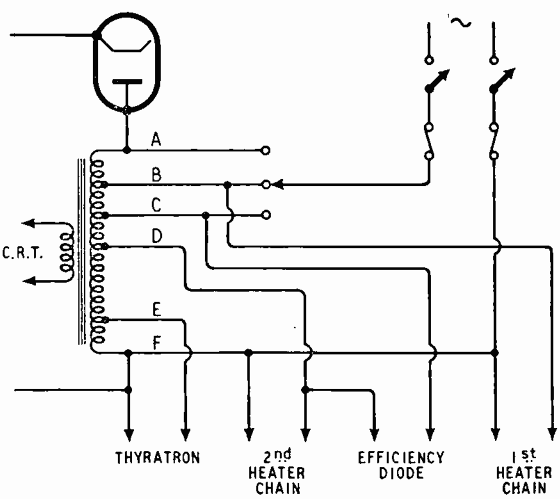


Fig. 1. Heater-supply circuit of the Ultra V814.

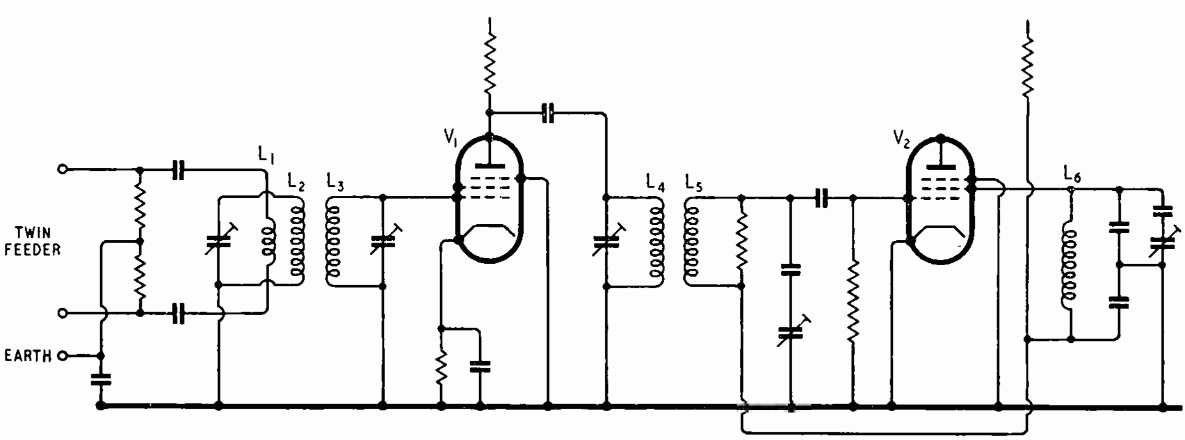


Fig. 2. Signal and frequency-changer circuits of the Philips TG1437U.

by L_4 and L_5. V_2 is the frequency changer. Apart from the number of signal circuits there are two other unusual features. One is the use of capacitance trimmers, the other is the adoption of plug-in coils. L_1, L_2 and L_3 form one plug-in assembly, L_4 and L_5 another and L_6 a third.

The use of four signal circuits is probably intimately connected with this plug-in system, for it is hardly more difficult to change four coils than two. With continuous tuning, however, the complications increase rapidly with the number of circuits.

An example of a more normal kind of r.f. end is shown in Fig. 3. It is of the G.E.C. BT5147 receiver and has continuous tuning for channel selection. A coaxial cable is used and coupled by L_1 to the first tuned circuit, which comprises L_2 and stray capacitance. Another tuned circuit L_3 couples the r.f. valve to the frequency changer V_2; L_4 is a fixed coil, not adjustable. The feeder is isolated from the receiver by a capacitor and can be earthed directly.

There are endless variations of detail on the r.f. side, but the general tendency seems to be to use coaxial feeder and two or three continuously tuned circuits. The tuning is usually carried out by movable cores in the coils. Sometimes these are ganged, but more often they are not. It is becoming increasingly common for the controls to be accessible from the rear of the set but in some cases they are still fitted internally. Station selection is then a matter for the dealer to carry out.

The commonest form of frequency changer is undoubtedly an r.f. pentode as a combined mixer-oscillator. The control and screen grids are used as the oscillator electrodes in a Colpitts or Hartley circuit and the signal is applied to the control grid. There are various ways of doing this. In Fig. 2, the oscillator coil L_6 is connected to the grid through the signal coil L_5. In Fig. 3, a shunt feed is used. Quite often, as in the Vidor CN4217 (Fig. 4), the signal is applied to the null point of the oscillator circuit. Save that the tap is on the inductance rather than on the capacitance, this is a technique which has been used for some years by Bush and is retained in their new models.

Murphy, however, have adopted an r.f. pentode mixer with a triode oscillator, the two valves being in a common envelope. They are also unusual in employing two r.f. stages and five signal circuits. The triode-pentode frequency changer is to-day more often used than in the past and it will be interesting to see whether it will oust the single-valve type now so common. A variant of the same form of circuit, but with a double triode, is used by Ferguson in the 998T.

In the vision i.f. amplifier two stages are common. The form of the couplings varies considerably, however. Three coupled pairs of circuits is quite a usual arrangement but some sets have one, or even two, of the couplings by single-tuned circuits only. Wave-traps are used to improve the sound-channel rejection, both of the wanted channel and of the adjacent channel. The Murphy V216C has four cathode traps but it is unusual to have as many as this. Probably most sets have two traps, some have one only and a few have three. In the sound channel there are two i.f. stages in most sets, but quite a large proportion have only one. In most cases there are three tuned circuits, but a few sets have four.

As already mentioned, the variations on the detector, video and audio sides are relatively small. The detectors and noise limiters are nearly always diodes, although sometimes of the germanium type. The video stage is nearly always a pentode and usually has an inductance-compensated anode load. Some extra cathode compensation is often used in the form of a small capacitance in shunt with the bias resistor. In one case, Murphy V216C, the cathode circuit is

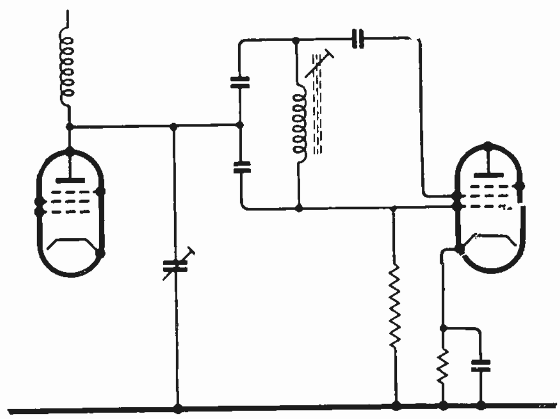


Fig. 4. *Frequency-changer circuit of the Vidor CN4217.*

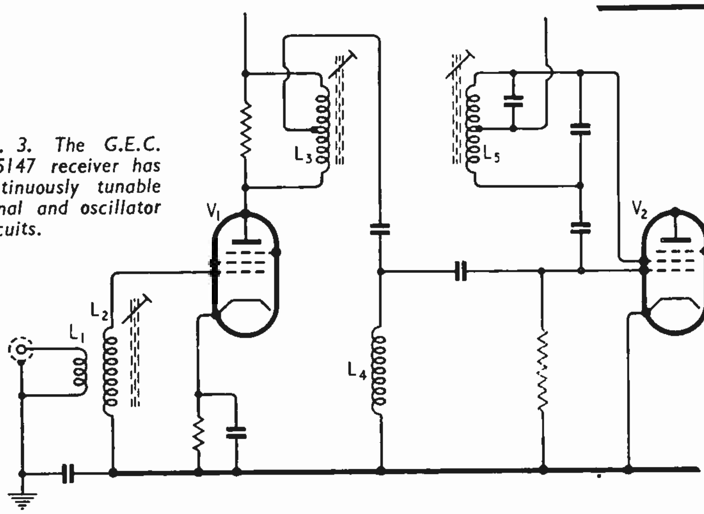


Fig. 3. The G.E.C. BT5147 receiver has continuously tunable signal and oscillator circuits.

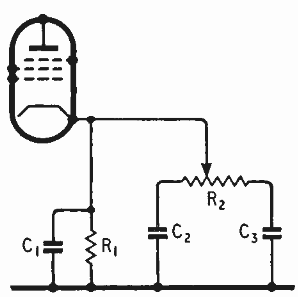


Fig. 5. 'Quality Control' circuit of the Murphy V216C.

adjustable to form a control of picture quality. The arrangement is shown in Fig. 5; R_1 is the bias resistor and C_1 is the usual small compensating capacitor. The capacitors C_2 and C_3 form with R_2 the quality control and operate by giving a variable response to the stage at the higher video frequencies.

Direct coupling between the anode of the video stage and the cathode of the c.r. tube is almost invariable, the few exceptions being rather special cases. The sync separator is fed from the video output and is, without exception, a pentode with low anode and screen voltages and d.c. restoration at the grid. The line time-base is usually fed from it through a differentiator and the frame through an integrator with a diode of some kind to separate the line pulses from the frame. Here, however, there is a good deal of variation in detail and it is fairly obvious that no one has yet found the ideal frame pulse separator.

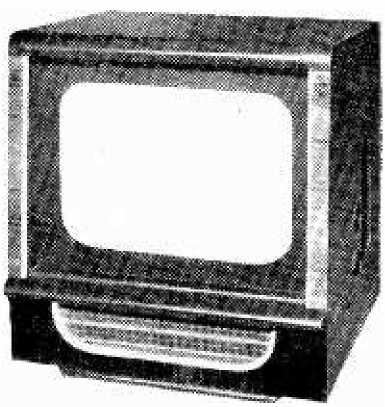
There are certain cases where special methods of synchronizing are adopted in an endeavour to render it less susceptible to noise and interference. These are of two basic kinds. In the first, pulse triggering of the time-bases is retained and the effect of noise is reduced by exceptional limiting. This is adopted in the Philips and Stella receivers in which four valves (two triode-pentodes) are used for sync separation, no fewer than three being in the line circuit. In Fig. 6, V_1 is the main sync separator and is of normal type. The separated pulses are applied to V_2 which is operated to have a grid base small compared with the pulse amplitude. It thus selects and amplifies a slice out of the pulses and only the noise on the pulse edges can get through. Its output is differentiated by C_1R_1 and applied to a further limiter V_3 which cuts off the negative-going (input) spikes of the waveform and delivers a negative pulse to the blocking-oscillator saw-tooth generator.

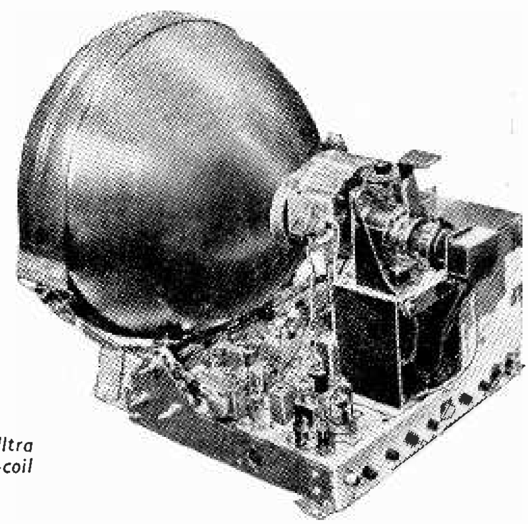
The pulses at the output of V_1 are also integrated by the double integrator $R_2C_2R_3C_3$ and applied to V_4. This valve is normally held in grid current but is cut off by the integrated frame pulses to provide pulses of anode current which, after some further integration, lock the frame blocking oscillator via the coupling coil L.

The whole essence of this method of noise reduction is, in effect, to select only a very narrow slice of the sync pulse. The circuit is unresponsive to noise except during the very short intervals of time when the pulses pass between the slicing limits.

The second method of attacking noise in synchronization is by what is called flywheel sync. The essence of this method is to make the synchronizing depend, not on individual sync pulses, but on the cumulative effect of a very large number. Although it is practically universal in the U.S.A. and a few examples of it were exhibited last year, it is still the exception rather than the rule. Only a few firms have adopted it as a standard part of all sets and a few more utilize it in their "fringe area" models.

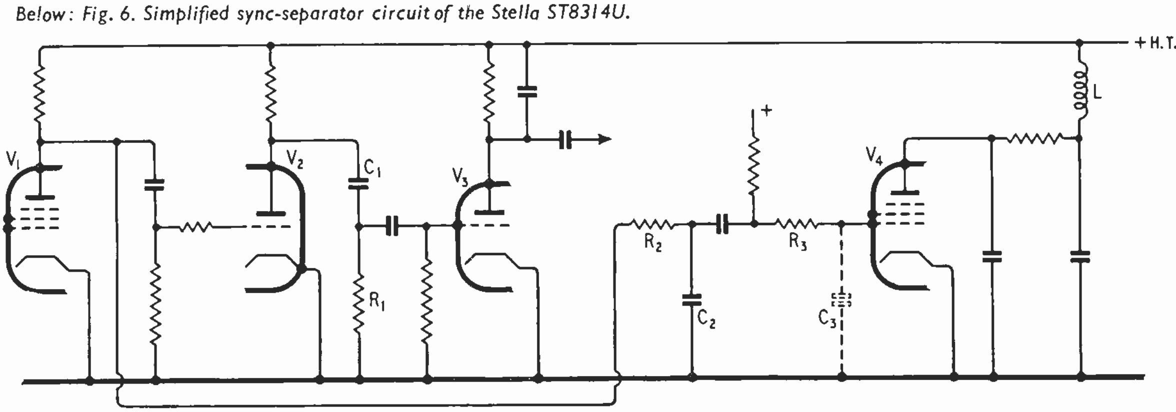
Pye retain the form which they introduced last





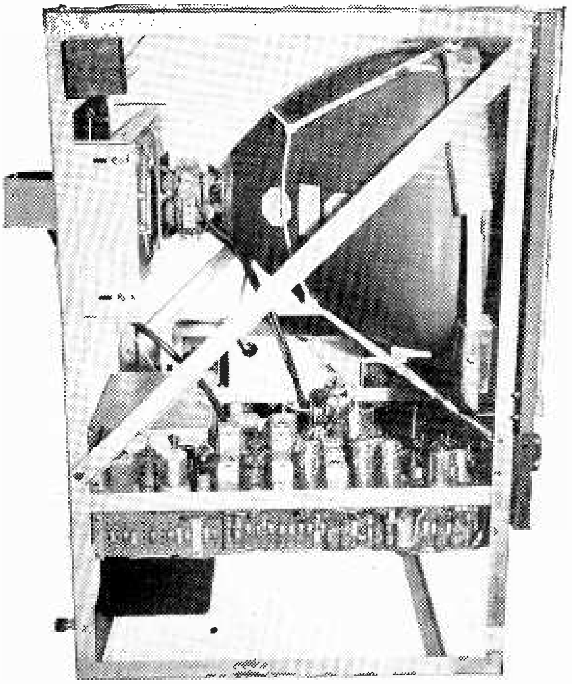
McMichael TM317 table model with a 17-in tube, and (right) Ultra television receiver with metal shroud around the deflector-coil assembly.

Below: Fig. 6. Simplified sync-separator circuit of the Stella ST8314U.



year[1]. Ferguson have retained a model (991T) which they brought out last year but, in a new model 998T, they have reverted to the conventional methods. The new model, however, is not a fringe-area type. English Electric have used a third form of flywheel sync for some years but, again, only for fringe areas. Murphy have now adopted flywheel sync for fringe areas only. It is fitted to the V214A and V216CA models. The arrangement used is somewhat different from the others and so deserves explanation. Referring to Fig. 7, L is a winding on the line output transformer and the transformer T selects the fundamental component of the scanning waveform to develop substantially a sine wave on its secondary. The diodes V_1 and V_2 conduct on alternate half-cycles of this wave and develop equal mean voltages across the equal load resistors R_1, R_2. These are connected to be in series opposition as regards the output circuit and so the total output is zero.

[1] *Wireless World*, October, 1952, p. 385.



Chassis of Dynatron TV27B ; the tube is mounted on the framework independently of the receiver.

Negative-going sync pulses are applied through C to both diode cathodes. If they coincide in time with an instant when the sine wave is passing through zero, both diodes conduct equally and the output is again zero. At any other instant, however, one diode has an effective positive bias and the other an equal negative bias from the sine wave and they conduct unequally when the sync pulse arrives. A net output voltage then appears and it has a polarity dependent on whether the sync pulses lead or lag in time on the sine wave and a magnitude dependent on the amount of lead or lag. The output is applied to a d.c. amplifier V_3 and thence to the time-base.

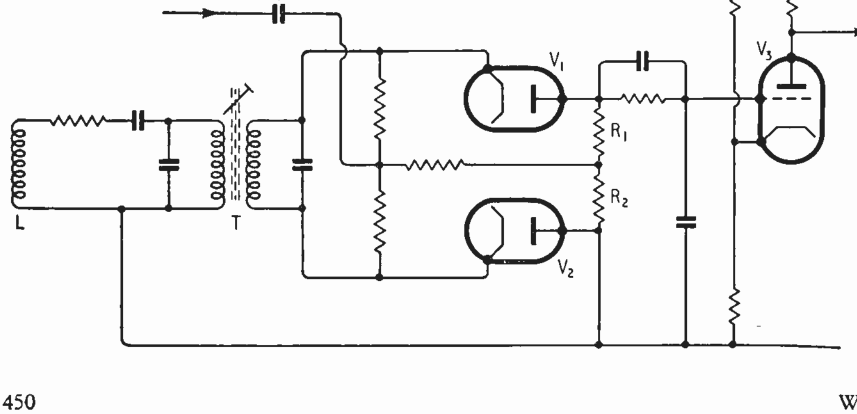
The present trend in flywheel sync is clear. It is to use it only for fringe area reception. Another refinement which is finding its way into television is vision-channel automatic gain control. It is far from common, although sound-channel a.g.c. is widely used. Again, there are several systems and they fall into two categories, those which are black-level operated and which tend to keep the black level constant and those which are picture-operated and which tend to keep the mean brightness constant. The latter are usually a good deal simpler.

Pye adopt a black-level control. The method has been previously described[2] and is quite complex. In essence, the video signal from a cathode follower is applied as bias to a d.c. restorer. Pulses are derived from the line time-base and delayed so that they occur during the back porch—the short period of black following each sync pulse. They are applied to the d.c. restorer and are d.c. restored to black level. Rectification and integration produce a bias voltage for an i.f. stage which is dependent on the black level of the signal. This automatic picture control, as Pye call it, tends to keep the black level of the picture constant.

The scheme adopted by Ekco is much simpler. It is shown in Fig. 8. V_1 is the main sync separator and is fed with the video signal through R_1C_1 in the usual way. The grid leak is formed by R_2R_3 and d.c. restoration occurs in the usual way. The mean grid potential of V_1 is negative to cathode by an amount which depends on both signal strength and picture content. The fraction of this voltage which appears across R_3 is applied in series with the steady voltage across R_5 to the integrator R_4C_2. The voltage across C_2 is applied to an i.f. valve as bias. It is a steady voltage, the value of which depends on the strength of the signal, the mean brightness of the picture and the voltage across R_5. This last resistance is variable as a manual gain control (contrast).

The diode V_2 is only to prevent the a.g.c. line from becoming positive to earth. If the signal is small and R_5 is set to develop any considerable voltage, the

Fig. 7. Flywheel sync circuit of Murphy V214A and V216CA.



[2] "Vision A.G.C.," *Wireless World*, April, 1953.

a.g.c. line tends to go positive. V_2 then conducts and clamps it to earth.

This simple system depends for its success upon the mean brightness of the picture being more or less constant. In fact, this is usually the case and it is only on the comparatively rare occasions when the producer calls for a near black or near white picture that his artistic effects may be marred.

Turning now to the time-bases, it is general for the line output circuit to be a pentode with an efficiency diode and auto-transformer coupling. H.T. boost and fly-back e.h.t. are practically universal. A boost of about 220 V is quite often obtained and e.h.t. supplies of 10-17 kV using a single-valve rectifier. The voltage used varies very roughly with the tube size and is of the order of 1 kV per inch!

The auto-transformer usually has a low-loss core and the magnetic circuit of the deflector coils is closed through a similar material. The so-called "castellated" yoke, which is derived from an earlier design using motor-stator laminations, is becoming more common. Higher efficiency is obtained because the magnetic material can be brought closer to the neck of the tube and a more uniform product results because the windings are definitely located in slots.

The only common variations in the output circuit of the line time-base are in the form of drive for the valve and in the linearity circuit. The use of a saturated coil, which was introduced two years' ago, is increasing in popularity, but many sets retain the resonant transformer. Sets are about evenly divided between saw-tooth and pulse drives for the output valve.

The single-valve self-oscillating line output stage, which a few years back was quite popular, is now comparatively rare. It is used by Ferguson in the new 998T, however, in the form of a pentode which is pulse driven on the control grid, the pulse being derived from a winding on the anode circuit transformer. This pulse drive is actually quite widely used but it is more usual to develop it with the aid of another valve, the two forming a multivibrator. Where a saw-tooth drive is used, the blocking oscillator is the favourite generator.

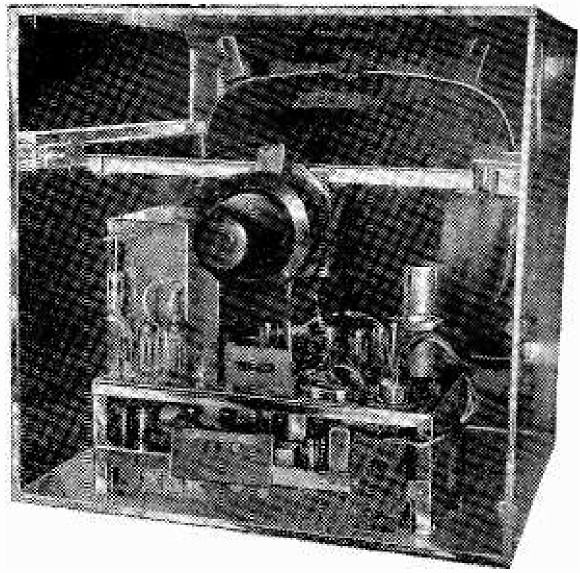
An exception to this general form of line time-base is to be found in the Bush TV22A and TV24A receivers, the new 9-in and 12-in models. A pentode is used, self-oscillating between the control and screen grids, and with directly fed deflector coils.[3] The necessary loading inductance is an auto-transformer for e.h.t.

In the frame circuit, transformer feed to the deflector coils is usual. Cossor use an auto-transformer, but this is an exception rather than the rule, and Ultra use an RC feed to a high-inductance coil. The Blumlein linearity circuit, or some variation of it, is still common, but there is an increasing tendency to use valve curvature for linearity correction and the linearity control is then merely a bias control on the output valve.

The frame saw-tooth generator is either a blocking oscillator or a multivibrator, but usually the former. Last year, the blocking oscillator seemed to be dropping out of favour and it is noteworthy that it is staging a come-back.

Focusing is nearly always by permanent magnet, but a few people retain the electromagnet, notably Kolster-

[3] "Simple Line-Scan Circuit," by W. T. Cocking, M.I.E.E., *Wireless World*, August, 1952.



Cossor television receiver with rectangular tube.

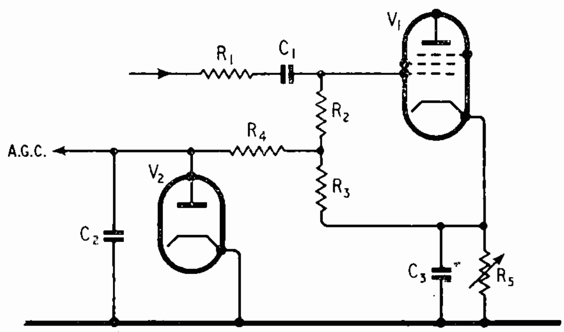


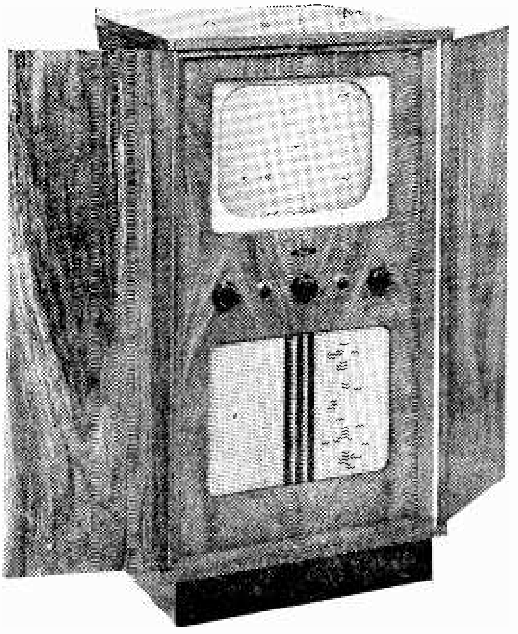
Fig. 8. Simple A.G.C. circuit of the Ekco T207.

Brandes and Philips. The use of centring magnets instead of tilting the focus magnet is increasing and has much to commend it, since it is not only theoretically superior but is practically easier to adjust. Tubes now usually have ion traps and so ion-trap magnets are fitted.

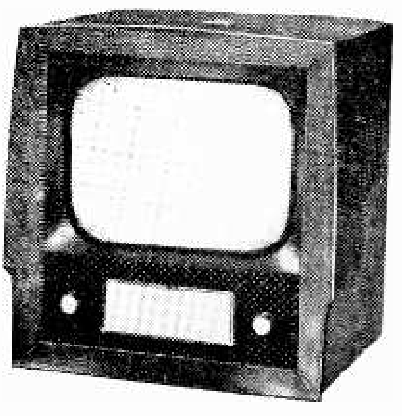
The size of television pictures is definitely on the increase. The 9-in tube is now comparatively rare and even the 12-in is beginning to look small. The 14-in and 17-in are now the more popular sizes and are commonly rectangular-faced tubes of some 70° deflection angle. Partly because of the reduction of size brought about by these two factors and partly because of the general use of miniature valves, the 14-in and 17-in tubes are widely used in table-model sets. This is quite an achievement, for it is not many years since a 12-in table model was rather a novelty.

The 17-in tube is the largest in common use, but there are considerably larger ones. H.M.V. showed the 21-in model which they introduced some time ago and Pye had a set with a 27-in tube! This has a deflection range of no less than 90° and is operated at 16.5 kV.

The grey viewing filter is now so widespread that the white faces of sets without them look a little strange. The white-face tube with tinted safety-glass,



Bush TUG34A with 14-in rectangular tube.



H.M.V. Model 1824 with 14-in tube. A black-spotter is used in the interference-suppression circuit.

however, shows signs of disappearing. The tendency now is for the end of the tube itself to be made of grey glass.

A new trend this year is for the tube to be mounted so that the screen is leaning forward very slightly instead of being vertical or leaning back. The amount of tilt often appears more than it is, since the safety-glass sometimes leans forward more than the tube face and the effect is often exaggerated by the lines of the cabinet. The tilt is introduced in order to reduce room reflections. The room lighting, which produces most of them, is usually above the level of the tube screen and by tilting the screen forward the reflection is brought below eye level.

Considerable attention is now being paid to picture presentation, of which the tilted screen is but one example. Ferguson have introduced an illuminated surround for the picture which they term Halolight. Fluorescent lamps are fitted so that the surround is lit by an adjustable amount. This is a technique borrowed from the cinema where it has been used experimentally for some time. Another refinement is spot-wobble, which has been fitted to some Ekco sets for the last two years. It is still used in their new model but is to be found in very few other sets.

Projection television is still employed for pictures larger than a 17-in diagonal. Ferranti, Decca and White-Ibbotson, among others, showed sets of this type. The domestic types are basically unchanged from previous years, but are improved in detail. Possibly because of the advent of the 17-in tube, projection television receivers appeared to form a smaller section of this year's exhibition.

Television Aerials and Accessories

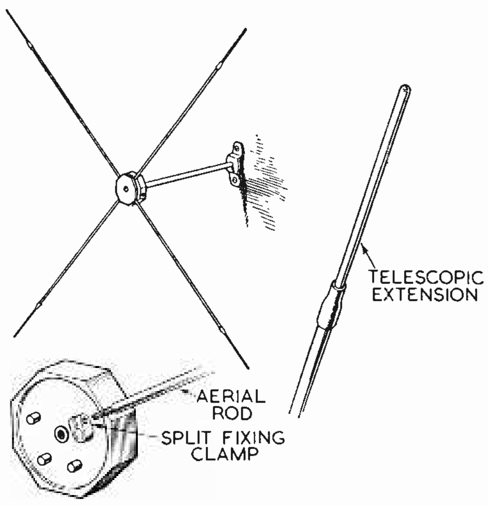
There are faint, but definite, indications that much wider use will shortly be made of indoor television aerials ; for, as the chain of medium- and low-power stations nears completion, more and more viewers will be brought within the strong signal service area.

Random lengths of wire will hardly ever be satisfactory as television aerials, although they may satisfy many sound broadcast requirements ; and an aerial of the correct length for the nearest station will have to be used. However, some liberties can be taken with the shape, and the rods, or their equivalent, may be bent or set at various angles in order to accommodate the aerial in the somewhat confined spaces available indoors.

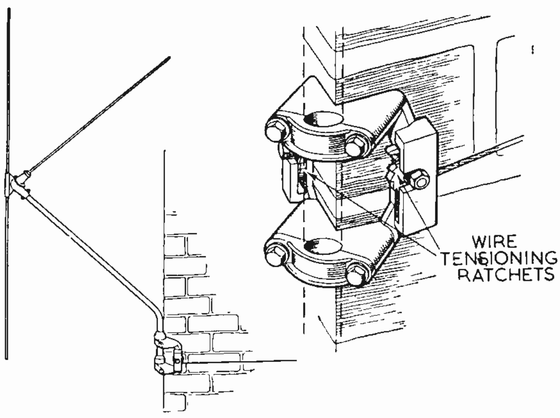
Makers of television aerials are well aware of the almost certain growing demand for less conspicuous types and give greater prominence to them at this year's show.

Considerable ingenuity has been displayed in the design of some of these new indoor models in order to make them as versatile as possible, and the Antiference " Univex " is a case in point. It has an octagonal centre insulator supporting four equi-spaced contact studs on which either two or four aerial rods are assembled. These are telescopic and readily adjusted in length to suit any of the five existing television channels. They can be secured in any position by simple split clamps which grip the studs when the elements are screwed in tight. Provision is made for horizontal or vertical mounting and a wide variety of aerial shapes such as " L," " T," " K," " X," etc., is possible.

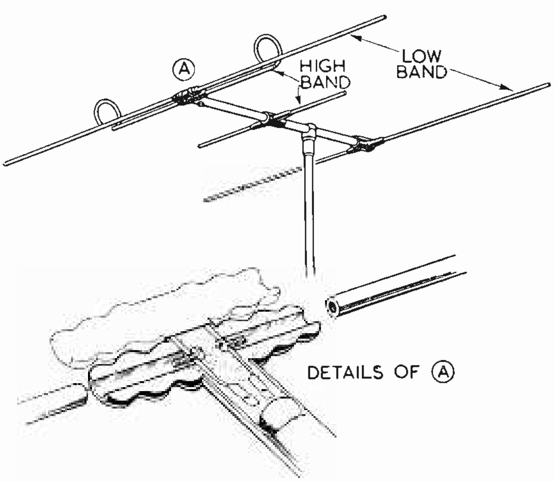
Pre-assembly of television aerials at the factory is a new departure, adopted by several firms as part of a general policy to facilitate assembly and erection as far as possible. The Belling-Lee contribution towards simplification is a new chimney-stack bracket having two ratchet-type wire tensioners for the harness, and these seem very much easier to handle than most other types of wire strainers. This bracket is used for the new Belling-Lee " Kayrod " aerial, which is intended for use in areas of moderate signal strength. It gives a performance about midway between a simple dipole and an " H." The straight arm of the " K " functions as a director, its length being very critical for best results owing to the proximity of the dipole element. The upper arm of the " K " is insulated and forms the top half of the aerial dipole and to this is joined the centre conductor of the co-axial downlead. The lower leg of the " K " behaves as a sleeved dipole



Antiference " Univex " versatile indoor aerial.



Belling-Lee " Kayrod " aerial and new ratchet chimney bracket.



Two-band television aerial developed by Telerection and arrangement of the centre insulators.

element and into it passes the feeder. It is electrically bonded to the director, but an insulator is used where it joins the ratchet chimney clamp.

The re-designed " Antex " by Antiference is an example of an outdoor aerial pre-assembled at the factory and despatched with all its elements secured in position, but folded flat. To open it to the familiar " X " form the elements are swivelled so that they drop into the grooves proved in the centre housing. A turn or two of the spring-loaded captive nuts firmly secures them. When swivelled into position the rods rest in short metal saddles, and, as rods and saddles are insulated, a capacitance of about 350pF is provided at each rod end. This capacitor is the only connection between aerial rod and feeder, but it is large enough to have negligible reactance at television frequencies. It is said that atmospheric corrosion of the ends of the elements will have negligible effect on the aerial, since its performance does not depend on good electrical contact between rods and fittings.

A new form of crossed dipoles in which both are driven elements, to use a transmitting term, has been developed by Aerialite. It is known as the " Unex," and both elements are electrically continuous and insulated from each other. They are assembled as four separate rods, one screwing into the other in each case, and in so doing make contact with an annular ring moulded into the centre housing. These rings form the connections for the feeder.

The two feeder conductors (inner and outer of co-axial type) are each joined to one of the dipoles, and as this forms an anti-phase arrangement the aerial would be bi-directional in the plane of the dipoles or " end-fire " as it is often called. If the top rod of one and the bottom rod of the other are fore-shortened the aerial becomes uni-directional, accepting signals from the side of the shorter rods.

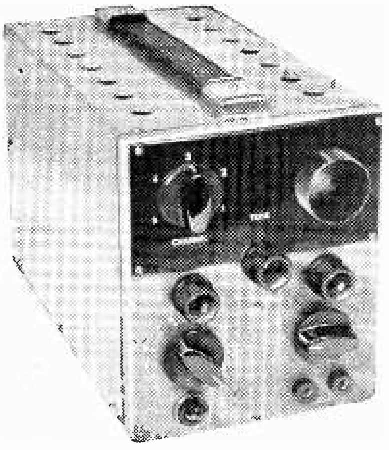
By fitting two fore-shortened rods in the upper positions of both dipoles (a vertical aerial is assumed here) a figure-of-eight response is obtained in the plane of the aerial with two well-defined nulls on either side and one below.

It is apparent from this brief description that quite a large number of polar diagrams can be produced merely by changing the element lengths. Actually what is occurring is that the phasing of the aerial is being modified, and this in turn changes the response characteristics of the aerial. A different set of characteristics can be produced by horizontal mounting.

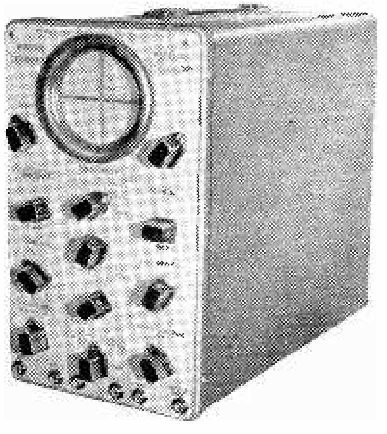
It was interesting to observe that quite a large number of polar diagrams of the new aerials were shown this year. It is apparent that considerable research has been carried out into the behaviour of television aerials, and the user can select the design best suited to his particular requirements, whether it be for best front-to-back ratio or best forward gain.

Should we have to consider television reception in more than one band what type of aerial will be required? One answer to this question is given by Telerection, who have developed some two-band aerials for overseas use. The general form is a 2-element horizontal " H " arranged as dipole and reflector for the lower frequency band. Just behind the dipole is a short reflector for the higher frequency band. On each half of the dipole is a stub which has negligible effect on the performance at the lower frequency, but behaves in such a way that it electrically fore-shortens the dipole at the higher frequency.

Three forms of this aerial have been evolved, one



Television field-strength measuring set made by Telequipment.



Taylor oscilloscope Type 31A suitable for television testing.

with stubs made of sections of rod with the ends joined by a loop, another in the form of "T"-match with an inductance loop (shown in the illustration) where it joins the dipole elements, while the third has short stubs set at an angle to the dipoles.

Apart from a few new aerial plugs, sockets, connections and distribution boxes the miscellaneous class of television accessories seems much as last year. One item that did attract attention was a small television field-strength meter developed by Telequipment. Basically it is a 5-channel television receiver consisting of an r.f. stage, mixer and 2 i.fs and the signal output is taken to a 1-in diameter cathode-ray tube. The actual picture content is not shown and the tube displays the maximum signal amplitude, or peak white.

The method of use is to plug in an aerial—a temporary one or even a short length of wire will often suffice—and adjust the gain controls so that the carrier just fills the defined space. The volume controls are calibrated in microvolts and by noting their readings the actual signal-strength level is obtained and with a little previous testing locally it is possible to predict with reasonable certainty the best type of aerial for good reception in any part of the district. This is but one of several applications for the test set, another is an interference level indicator, as a good idea of the signal/noise ratio is provided by the amount of "grass" accompanying the signal pattern as shown on the tube.

Another item of test gear intended primarily for television servicing is the Type 31A oscilloscope just introduced by Taylor Electrical. It is a versatile 'scope fitted with a hard valve linear time-base covering 10 c/s to 500 kc/s nominal and an "X"-amplifier giving a linear amplification up to as much as some 10 screen diameters.

A push pull "Y"-(work) amplifier is included and this gives the equivalent of 5 screen diameters and a sensibly flat response from 10 c/s to 6 Mc/s. The oscilloscope is a.c.-operated, measures $1\frac{1}{2} \times 7\frac{1}{4} \times 15$ in and weighs 26 lb.

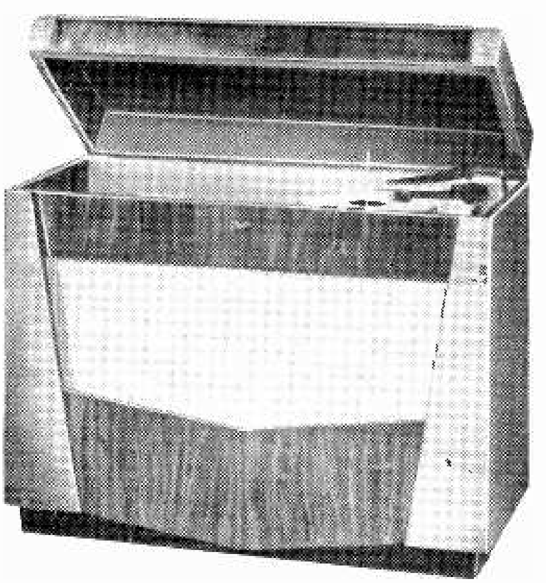
Although having no television label the 25-kV multipliers developed by Avo for the d.c. voltage ranges in their multi-range meters of suitably low consumption qualify for inclusion here as they are for measuring e.h.t. voltages in television sets.

SOUND RECEIVERS

THE stability of the table model superheterodyne (4 stages, plus rectifier) as the basic receiver for sound broadcasting remains undisturbed by any startlingly new development. So far as the number of types available is concerned, however, it is being challenged by the console-type radio-gramophone, largely due to the introduction by a number of firms of inexpensive models in the price range £48–£58. Typical examples are the Ambassador "Coronet," Champion 808, G.E.C. BC9440, Marconiphone ARG33A and Regentone Multi 99.

Two new portable radio-gramophones have made their appearance ; the Pamphonic 902 and HMV 1507. Both are fitted with 3-speed turntables and the HMV model is notable for the fact that the latest type of ceramic piezoelectric elements are used in the cantilever, turnover pickup.

A minor trend is the increased use of elliptical loudspeaker diaphragms, which have been consistently favoured by E.M.I. in all sizes, and are now used by other firms in solving a variety of layout problems where space is limited. In the Sobell Type 514TAG table



Marconiphone ARG33A radio-gramophone.

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Reliability is especially important in the modern T/V Receiver which employs four times as many valves as radio and — fewer rejects in the factory will mean fewer failures in the field !

The Brimar 6AM6/8D3 and its direct equivalents the Z77, SP6, EF91 and 6F12 have been some of the most widely used valve types in post-war Television Receivers. Large quantities have been used in the following Manufacturers' sets :—

BAIRD	K-B
BUSH	MARCONIPHONE
COSSOR	MASTERADIO
ENGLISH ELECTRIC	McMICHAEL
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Use the improved BRIMAR 6AM6/8D3 to replace these valves at NO EXTRA COST

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First of the "Hi-g" Pick-ups

Now available to gramophone manufacturers

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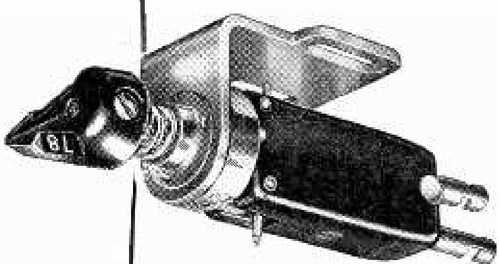
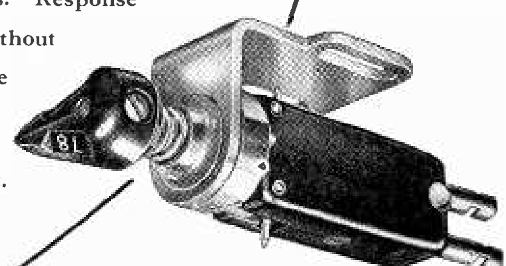


TURNOVER PICK-UP CARTRIDGE TYPE HGP 33-1

Here it is—the HGP 33, capable of tracking the highest modulation levels that can be engraved on either standard or long playing records.

Nominal output is one volt on standard records and ¼ volt on long playing records. Response is smooth and completely without resonances. Equalisation can be easily carried out if required.

Technical Data Sheet on request.



1. *Extremely high compliance and low mass.*
2. *Styli easily replaceable without tools.*
3. *Completely hermetically sealed crystal unit.*
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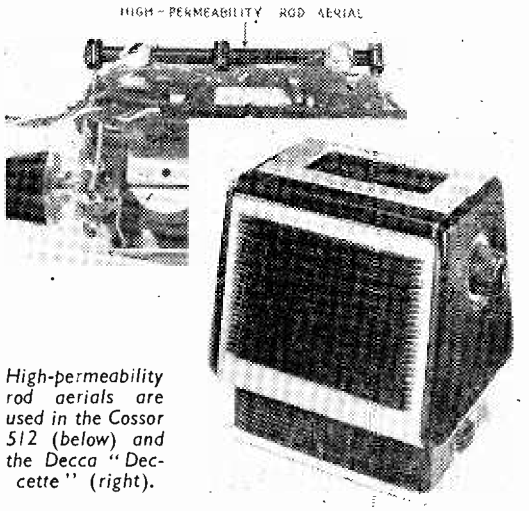
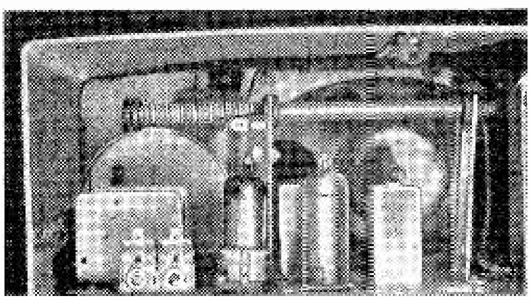
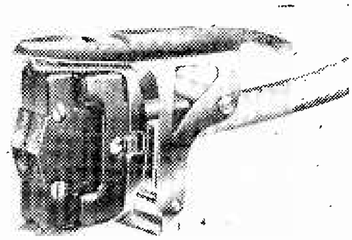
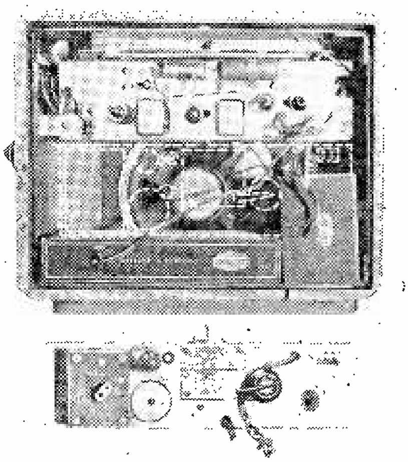


High-permeability rod aerials are used in the Cossor 512 (below) and the Decca "Deccette" (right).



Ceramic (barium titanate) elements are used in the latest H.M.V. pickup (right).





Bush battery/mains portable Model BAC31.

radio-gramophone, for instance, the loudspeaker is fitted into the front *edge* of the cabinet lid.

Probably the most interesting development is in portable receivers, two of which (the Cossor 512 and the Decca "Deccette") are fitted with internal aerials consisting of a ferromagnetic rod core, and windings no greater in diameter than a conventional tuning coil. The r.f. pick-up of this arrangement is comparable with that of a frame aerial of the size which can be accommodated in a small cabinet, and it exhibits similar directional properties. Inevitably, the introduction of a core brings with it losses which are not associated with an air-cored loop, but most portable frame aerials would be better described as "receiving-set-cored." The decision as to which method will give the best results will depend on the circumstances of layout, dictated by the external form which the receiver is to take, and it should not be implied that a manufacturer is out of date because he uses the conventional frame. In Germany the *ferritstab* aerial was used in most small portables a year ago, but there are signs that designers there are having second thoughts about what was at that time a slavishly followed fashion. If earlier extravagant claims have been modified, there can be no doubt that properly handled—and it is by no means simple to design—the rod aerial can increase the flexibility of portable set design.

Another trend in small portables is to make them primarily as battery receivers, and to provide a mains supply unit as an accessory. This policy has been followed in the Bush BAC31 in which the power unit can be purchased later and takes the form of an additional chassis strip, which can be fitted internally by the user, with the aid of simple instructions and a screwdriver. In the Decca "Deccette" the mains supply unit is housed in a separate moulding and forms a plinth for the receiver.

The Philips 523UB mains/battery portable provides facilities for re-activating the dry batteries, to extend their life.

SOUND REPRODUCTION

THE growing interest in magnetic recording is reflected in the wide range of equipment now available for domestic and professional use. E.M.I. make all types from broadcast studio equipment (Model BTR/2) to a small battery-operated portable (Model L/2) in which the tape driving motor is energized from dry cells in parallel. In the Boosey and Hawkes portable "Reporter," the tape mechanism is driven by a clockwork motor.

Most tape recorders have two tape speeds, 7½ and 3¾in/sec, but in the Rudman-Darlington "Reflectograph" a novel continuously-variable capstan drive is now used which gives a speed range of 3¾ to 8in/sec. Not only does this permit exact adjustment of pitch, to compensate for daily variations in mains voltage, but speeds can be chosen to fit programmes of different duration into spools of standard tape length.

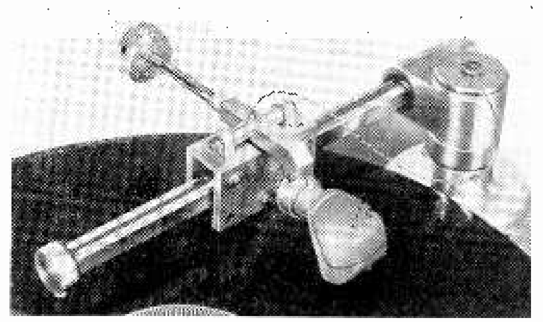
Instead of the conventional cylindrical friction drive between motor and flywheel, a ball drive is used. The photograph and sketch, reproduced below, show that the motor frame can be tilted by a calibrated screw adjustment, so that the circle traced on the ball by its point of contact with the flywheel face can vary in diameter from zero (when the motor shaft is perpendicular to the flywheel face) to the full diameter of the ball when the shaft is parallel with the face. In practice, of course, the shaft does not reach the vertical position ; an additional precaution against permanent depression of the Neoprene surface is provided by an auxiliary mounting bracket which automatically lifts the motor clear when it is switched off. As the tilting axis of the motor coincides with the centre of the ball, only a single line of contact of constant diameter is made on the flywheel. Industrial as well as domestic versions of this machine are available and, in one of these, four hours' playing time is obtained with excellent speech quality at 1in/sec using a 1200-ft reel.

Simon Sound have introduced a very professional looking twin-channel monitoring recorder for airports, using magnetic tape and giving four hours' duration on 2400-ft reels. By an ingenious system of overlapped mounting for the spools, the equipment is accommodated on standard 19-inch instrument panels.

Baird, who were early in the market with a portable tape recorder, have now entered the industrial field and make an industrial model (Type TRS1) for vibration study and other applications.

On the disc reproducing side, there has been plenty of activity, and Collaro are now at the production stage with a " transcription " motor, with a turntable weighing $8\frac{1}{2}$lb. All their 3-speed turntables are now fitted with an ingenious spring-loaded centring device for the large-hole 45-r.p.m. discs. This is automatically depressed below the turntable level when using 78 and $33\frac{1}{3}$ r.p.m. records, and, unlike the separate centring-spiders often used, cannot be detached and lost.

Garrard's latest record changers extend their already wide range with a high-quality unit (Type RC90) which is finding ready sales abroad, and an



Radial-tracking pickup arm (Classic Electrical).

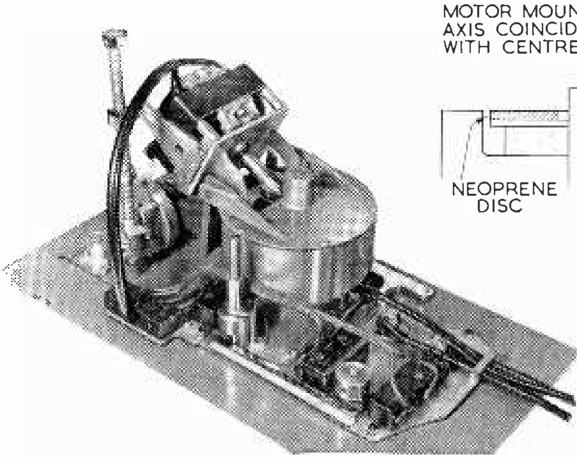
inexpensive unit (Type RC110) which has enabled many manufacturers to reduce considerably the price of radio-gramophones for the home market (as reported in another section of this review).

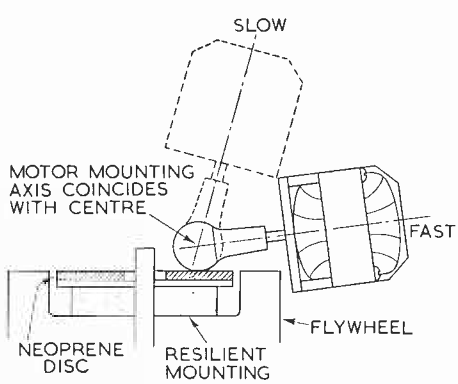
The Philips " Featherweight " 3-speed record changer, which has hitherto been obtainable only in radio-gramophones or record players, is now to be sold as a separate component (Type AG1000).

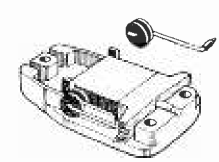
Some interesting new pickups have made their appearance. The ceramic cantilever piezoelectric pickup, as used in the Model 2126 record player and Model 1507 radio-gramophone, is a new departure for H.M.V., who have hitherto favoured the magnetic type. It is, we believe, the first commercial appearance in pickups in this country of the barium titanate type of element, with its advantages of thermal stability and resistance to the effects of moisture. This substance is, however, fragile and requires careful mounting ; in the H.M.V. pickup a pivoted guard affords protection from gross mishandling.

The Acos " Hi-G " pickups which are designed to track the severest accelerations (of the order of 2000 times the acceleration due to gravity) which can be recorded on discs, and which have hitherto been sold only to manufacturers, will now be more generally available. In the HGP37 series the makers have

Under-side of the " Reflectograph " tape recorder, and (on right) details of the continuously variable ball drive.



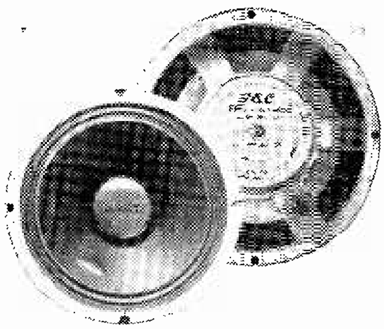


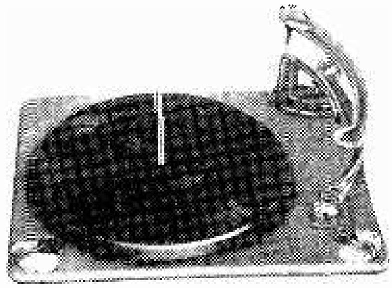


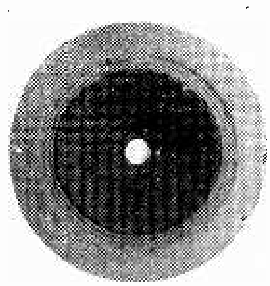
Acos Type HGP37 cantilever crystal pickup.

Goodmans Z33 moving-coil microphone.

Left : Double - element crystal microphone, Type Mic 35 (Acos).





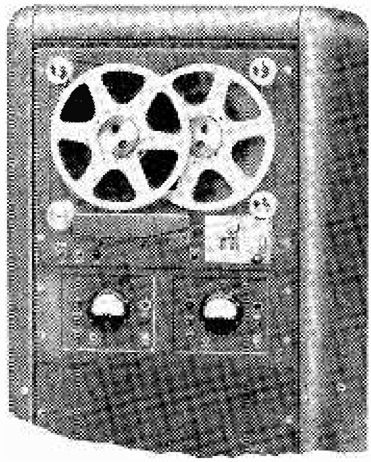


Left: Production-model "FR" metal-cone loudspeaker (G.E.C.). Centre: Garrard Type RC110 3-speed record changer. Right: Composite cambric diaphram used in Whiteley Electrical Type HF loudspeakers.

returned to cantilever mounting for the stylus, which drives the crystal element through the compliance of a specially graded plastic moulding. The cantilever anchorage is of simple design and can be easily replaced. The system is said to be truly aperiodic throughout the frequency range, the effective mass at the point is 7 milligrams and the compliance 3.5 to 4.0×10^{-6} cm/dyne.

A beautifully made radial tracking arm is under development by Classic Electrical to overcome distorsions due to tracking errors. Less than 3 grams is required to propel the carriage, and to reduce friction to this extent knife-edge rollers running, on miniature ball races, in a hardened and ground groove have been used.

Two new microphones have made their début. The Goodmans Z33 is of the moving-coil type and is mounted on a "wire" base formed for equal convenience as a desk stand or pocket attachment; a tapped hole is also provided for stand mounting. The Acos Mic 35 is an ingenious double-element design in which two diaphragm-driven crystals are connected in parallel, and in phase in the sound field. It is claimed that in addition to enabling characteristics of two different elements to be combined to give a smooth overall response at low cost, the arrangement gives some measure of noise suppression when used as a close-talking microphone.



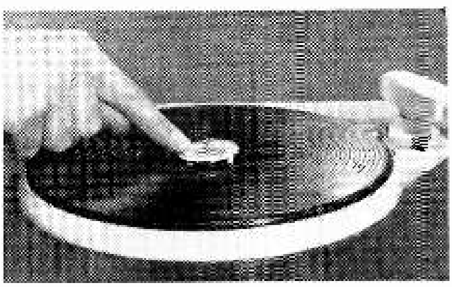
Twin-channel monitoring recorder, Type LDT7 (Simon).

An inexpensive loudspeaker with quality of reproduction above the average has been produced by Whiteley Electrical. The diaphragm is a pressing of open-mesh cambric backed by a light felting over the active area of the cone, the whole being cured together after pressing. The effect is to give a freely suspended movement of low mass which gives very effective reproduction of transients.

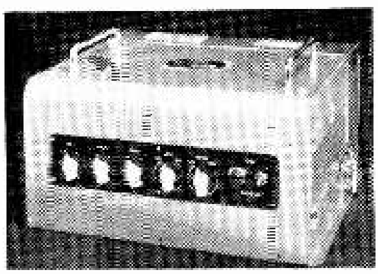
Comprehensive demonstrations of high-quality reproduction were once again staged by Goodmans and G.E.C., the latter with the production models of their metal-cone loudspeaker, which was shown in the experimental stage last year.

One of the oldest firms in the loudspeaker business, Baker Selhurst, made a welcome reappearance at the Show and demonstrated a special unit for low frequencies as well as their wide-range "de luxe" units in which a domed metal apex to a paper cone with two rates of curvature combine to cover frequencies from 18 to 17,000c/s.

Two new amplifiers for high-quality enthusiasts have been added to the already wide range of Trix products. The T635 is a 30-watt amplifier with inputs for two ribbon or moving-coil microphones and a gramophone pickup. It has independent bass and treble controls and can be switched to work from a 6-volt external battery or (normally) from a.c. mains. The T102 has been designed for use by gramophone



Spring-loaded 45 r.p.m. centring device (Collaro).



Type 635 30-watt gramophone amplifier (Trix).

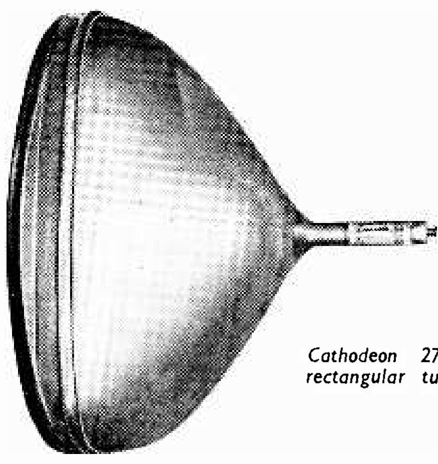
societies and is compact and easily carried. It has an output of 12 watts, and is fitted with wide-range base and treble controls.

VALVES AND CATHODE RAY TUBES

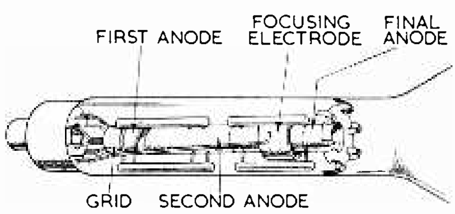
MOST television set makers are now featuring the 17-in rectangular tube in their latest models, so there is no doubt that this size of tube has come to stay. Although there is some talk of a reversion towards the 9-in size (perhaps because owners of big-tube receivers are finding it difficult to pay for tube replacements), it seems fairly certain that the future trend of design will be towards even larger screen diameters. Cathodeon, for example, have just brought out a mammoth rectangular tube with a 27-in screen and a deflection angle of about 90 degrees. It has a tetrode gun and the anode voltage is about 18 kV. E.M.I. are still producing the 21-in metal tube that they introduced two years ago, and we understand that one or two other manufacturers may be coming out with new tubes of this size.

A rather more down-to-earth design trend has been the reshaping of existing sizes of tubes so that they take up less space in the cabinet. More and more types are being made with wider deflection angles and consequently shorter lengths. Usually the wide deflection angle is about 70 degrees, but in one experimental 12-in tube made by G.E.C. the reshaping process has been taken even further to give an angle of 90 degrees and a reduction in length of over 5 inches. The deflector coils have to be specially designed for such wide angle scanning, of course, but existing types of output valves can apparently be used in the time bases.

Rectangular tubes are another way of saving space



Cathodeon 27-in rectangular tube.



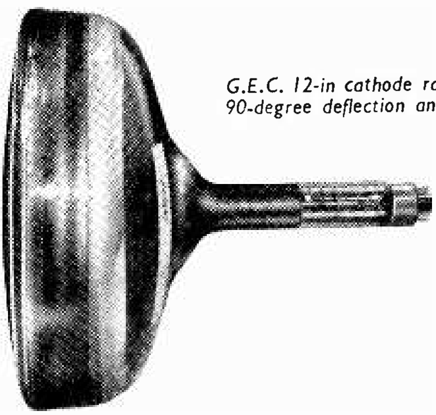
Electron-gun construction of Brimar electrostatically focused c.r. tubes.

in the cabinet—although Ediswan have pointed out that their new 14-in round tube CRM141 actually gives a picture of greater area than that of a 14-in rectangular. The secret is, of course, a little judicious corner-cutting. On the other hand, G.E.C. take an entirely new line in introducing their 17-in rectangular tube, 7401A, by pointing out that it can be arranged to give a picture with nice square corners, like that of a projection receiver! Incidentally, the Ediswan CRM141 has an improved type of ion-trapping tetrode gun which not only stops the negative ions from getting to the fluorescent screen but also prevents the positive ones from bombarding the cathode and poisoning it. The secret of this is a slanting electrostatic lens formed between the first and final anodes.

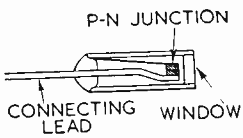
Other manufacturers seem to be showing some interest in electrostatic methods of focusing the beam. Indeed, two recent tubes made by Brimar, the C14GM and C17GM, are entirely focused by electrostatic means—a reversion to the early days when all tubes were of this type. They use an extra electrode at near cathode potential inserted between the penultimate and final anodes. The main advantages of this system are its simplicity and avoidance of external focus magnets. Usually, the fineness of electrostatic focusing is about the same as magnetic focusing, but Brimar claim that their electrostatic tubes are actually better. They also say that the focus does not change so much with variations of final anode voltage. A similar electron optical principle is used by Mullard in one of their recent magnetically-focused tubes, the MW43-64, and here the object is to improve the uniformity of focusing over the whole screen. The pre-focusing action of the electrostatic lens formed by the extra electrode makes the beam narrower than in an ordinary tetrode, so there is less deflection defocusing at the outer edges of the picture. Judging from recent American experience, however, it is questionable whether there will be a complete swing-over to electrostatic focusing. For one thing, the electrode structures of the tubes are rather more difficult and costly to manufacture than those of ordinary tubes.

It seems, too, that manufacturing problems are really at the heart of the old triode-versus-tetrode controversy, which has recently flared up again. Some firms have adopted the tetrode exclusively, while others insist that it is not really any better and continue to produce their latest tubes with triode guns. The main advantage of the tetrode would seem to be that the tube characteristics are not affected by variations in the final anode voltage, so that the picture brightness remains more constant. On the other hand, the triode is supposed to give a spot that is less prone to astigmatism, so that the definition of the picture may be somewhat better. It is often stated that because the electron beam of the tetrode is narrower than that of the triode it requires less focusing power and is not so liable to deflection defocusing. Defenders of the triode, however, reply that there is no reason why its beam should not be made equally narrow. They also say that there is nothing to prevent ion traps from being fitted to triodes—although apparently this is not quite so easy to do as in tetrodes. The fact that the Americans use the tetrode exclusively is not particularly significant—they just didn't happen to think of the triode first.

With the cost of replacing cathode-ray tubes as high as it is at the moment, many people will be interested in a new English Electric scheme for recon-



G.E.C. 12-in cathode ray tube with 90-degree deflection angle.



Construction of S.T.C. germanium junction photocell.

Right: Mullard EF86 low-noise pentode.

ditioning their 16-in metal tubes, which normally cost over £22. When a tube fails (beyond the 6 months guarantee period) it can be exchanged for a reconditioned one, carrying a new guarantee, for £12. The reconditioning process consists of cutting off the neck of the tube, fitting a new gun and renewing the fluorescent screen.

Developments in valves this year have not been very spectacular, but there have been some steady improvements in design, particularly in mechanical construction. It is said, in fact, that the technique of reliable valve production is having such a beneficial effect on ordinary valves that there will soon be no need to distinguish between the two kinds. One rather interesting example is to be found in the Osram television booster diode U329. A high heater-to-cathode resistance is needed for this type of valve, so the makers use a thin layer of vacuum—in other words, they space the two electrodes apart. The arrangement is claimed to be much more reliable than the usual insulating ceramics, which are rather prone to electrolytic action.

On the score of electrical efficiency the latest range of Mullard B7G battery valves are a notable achievement, for they have a filament consumption of only 25mA. This firm also have a new B9A pentode, the EF86, intended for a.f. voltage amplifying stages, which replaces their EF37A or EF40. Its mechanical construction has been designed to avoid microphonic tendencies, and the bi-filar heater reduces hum to a minimum. A similar valve from another manufacturer is the Osram Z729, notable for its low hum-level of 1.5 μV.

Osram have also produced two high-slope B9A valves, primarily for television applications. The Z309 is a short-base r.f. pentode intended as a video amplifier and has a slope of 15 mA/V; while the Z719, designed as an r.f. or i.f. amplifier, has a slope of 7.4 mA/V. In the Z719 two cathode connections are provided to reduce input circuit damping, while the low anode voltage of 170 V makes the valve particularly suitable for transformerless receivers. For stabilizing the series heater current in these receivers against mains fluctuations, and thereby prolonging the life of the valves and tubes, this firm have introduced a barretter, type 305. With a control range of 40-90 V, it maintains the current within $\pm$5 per cent of the nominal value.

Turning now to the topical subject of crystal valves, Mullard have entered the germanium field with two crystal diodes, OA60 and OA61, and two point transistors, OC50 and OC51. The OC50 transistor is a general purpose type, while the OC51 is intended for switching, gating and computing circuits. The G.E.C. type GET1, which has already become well known as an experimental transistor, is now in production and is available to manufacturers in sufficient quantities for experimental work. The current gain is greater than 2, the " knee " voltage is less than 3 and the collector current at −30 V for zero emitter bias is less than 2 mA.

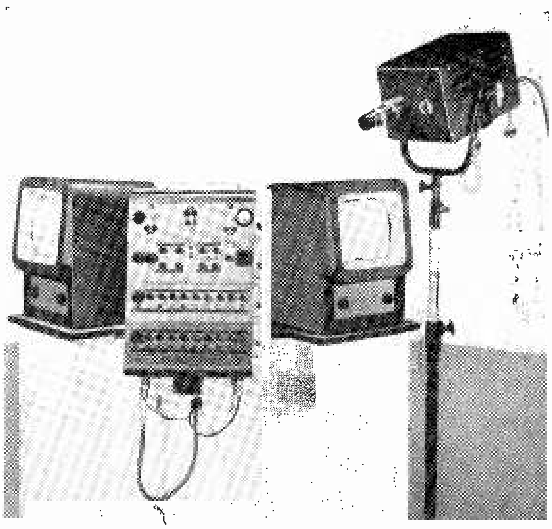
Apart from transistors, the most interesting germanium device to come on the market recently is the germanium junction photo-electric cell. Made by S.T.C., it consists of a *p-n* junction mounted in a metal cylinder of about ¼in diameter, with a glass window at one end and a connecting wire at the other. If the junction is biased at about 50 V in the reverse direction it passes a saturation current which is practically independent of the applied voltage, and when it is illuminated this current increases in direct proportion to the light intensity. The current varies between about 250 μA and 2.5 mA so the cell can be used for direct operation of a relay. S.T.C. have also introduced a power rectifier using a *p-n* junction. With a resistive load the maximum input voltage is 100 V, the peak inverse voltage is 140 V and the maximum mean d.c. output current is 100 mA. The germanium element is hermetically sealed with glass-to-metal seals and the complete assembly is about the size of a halfpenny.

OTHER EXHIBITS

AMONG the electronic exhibits arranged by the Radio Industry Council was an unusual type of machine for separating discoloured peas or beans from good ones. Instead of a mechanical system to do the final sorting it used electrostatic deflection. The beans are fed from a hopper on to a moving belt and then shot through an illumination chamber, where they are viewed by two photocells from opposite sides. A discoloured bean causes the photocells to produce a signal, which is amplified and applied as a negative cut-off voltage to the grid of a large valve. As a result the anode voltage of the valve rises momentarily to about 25 kV, and this high potential is applied to a point electrode so that the discoloured bean receives an electrostatic charge in mid-flight. After leaving the photocells the beans fall in a stream between two deflecting plates which carry a charge of about 25 kV, and the discoloured ones are attracted to one side out of the normal trajectory so that they fall into a separate container. The apparatus was designed by the machinery department of R. W. Gunson, the seed merchants.

The increasing use of radio heaters in industry was exemplified by a new Redifon dielectric heating equipment for welding plastic sheet. Its main feature is that the welding electrodes are in the form of a pair of "tongs," which can be taken to the work on the end of a coaxial cable, instead of being incorporated in the main body of the equipment. With varying thicknesses of plastic to be welded, the impedance of the capacitor formed by the two electrodes may be anything from about 2Ω to 60Ω, so an impedance-matching device has been incorporated to ensure that the maximum r.f. power is applied. It consists of a coaxial stub and has to be adjusted according to the thickness of the dielectric. The single-valve oscillator used in the equipment has an output power of 450 watts at 35 Mc/s.

One of the very latest electronic aids to industry is, of course, the closed-circuit television system, and there are now two firms making the apparatus in this country. The E.M.I. equipment consists of a camera, a control panel and a television receiver. The camera, which weighs 28 lb, uses a miniature C.P.S. Emitron pick-up tube and can be adjusted to cover a highlight brightness range of 10 to 100,000 ft-lamberts. There is also an electronic system for magnifying the picture up to twice the normal size for close inspection. If necessary the optical focusing and lens selection can be done remotely from the control panel. The Pye equipment is an improvement on their previous design in that the entire picture-generating apparatus, including the power supply, is contained in the camera itself—excepting, of course, the monitor on which the pictures are remotely displayed. Both equipments work on the British television standards, and their pictures can be displayed on domestic receivers—the Pye one having an r.f. output which can be tuned over all the B.B.C. channels.

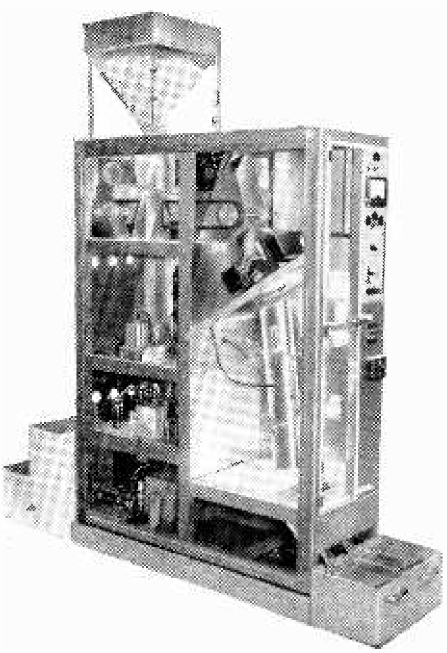


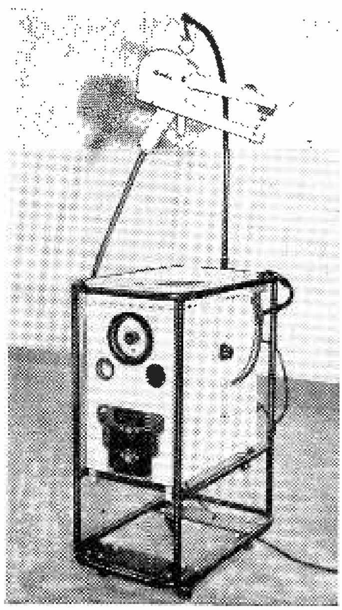
Another electronic system for transmitting visual information was the Creed "Desk-Fax", a small phototelegraphy equipment designed for sending written or typed messages over telephone lines. It operates on well-known principles and the received message is reproduced by a stylus on voltage-sensitive Teledeltos paper. The scanning is done at 100 lines to the inch, and a typewritten message of 150 words, occupying an area of approximately 15 square inches, takes about two minutes to transmit. The same machine is used as both transmitter and receiver.

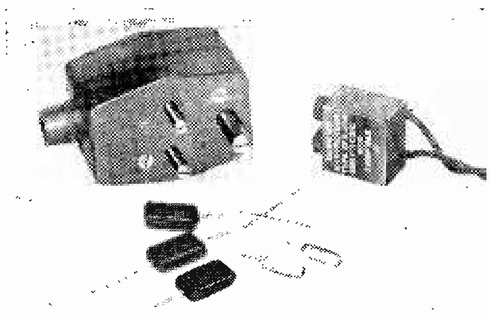
Among the latest test equipment is a new valve tester made by Avo. Known as the Type 160 it tells a little more than usual about a valve and covers such tests as cathode-heater insulation, inter-electrode insulation, mutual conductance up to 20 mA/V, amplification factor and a.c. resistance. It is a.c.-operated, weighs 22lb and accommodates almost every type of valve in current use.

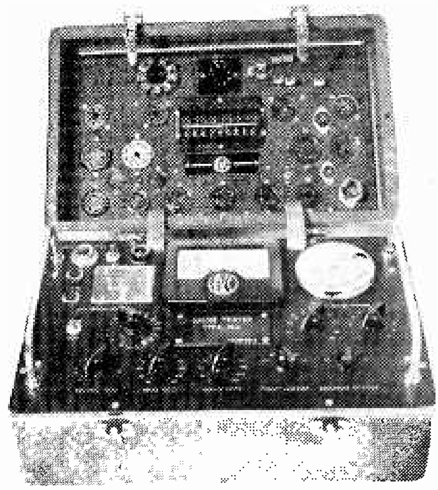
Electrical interference is still a serious nuisance to broadcast and television reception and while the technique of suppression is well known, convenient forms of suppressors for use in the home and on domestic electrical equipment have been scarce. Dubilier has introduced a series of suppressed plugs in 5-A, 13-A and 15-A types; the 13-A model includes a fuse. Suppressor capacitors of 0.1 and 0.05 μF are embodied in the plug. These are made of hard rubber and should be very durable. Alone, these plugs are effective on the medium and long wave-bands only and not at television frequencies. For this there is a

Machine for sorting peas or beans, using electrostatic deflection method of separation, and (right) radio heater made by Redifon for plastic welding.









Above : Dubilier interference suppression components for sound radio and television.

Right : Avo valve tester Type 160 for comprehensive tests on all modern valves.

Left : Industrial television equipment made by E.M.I.

range of Dubilier suppressors embodying chokes as well as capacitors and a kit of components for use on the actual offending appliance. A 3-pin, 5-A plug made of bakelite and containing suppressor capacitors is made also by Belling-Lee. The capacitors used in this model are 0.05 μF.

People who make capacitors are obviously in a good position to say how they should be measured and tested. Hunt's have introduced a capacitor tester comprising an orthodox Wien bridge, with a few refinements. An unusually large, high-grade potentiometer is used for the adjustable ratio arms and to obviate multiplicity of scales the multipliers are in steps of 100. The coverage is 20 pF to 500 μF in three ranges and power factor and leakage are also measured. The bridge also serves for resistance and insulation measurements so three resistance ranges are included, covering 5 Ω to 100 MΩ. Insulation testing is provided for but not actual measurement of leakage resistance.

AVIATION RADIO

Trend in Development as Seen at the S.B.A.C Flying Display at Farnborough

WHILE the radio show at Earls Court was in progress another exhibition of radio and radar equipment was staged at Farnborough, where the Society of British Aircraft Constructors were holding their annual flying display. A wide range of equipment was shown, including aircraft communication sets, navigational aids, ground station installations and various electronic apparatus connected in one way or another with flying.

If doubt has even existed that the higher frequencies covering the band 2 to 20 Mc/s have no future in aviation radio the newest of the communications equipments should finally dispel such opinions. There is a definite demand for this type of apparatus but in a different form to that used in the past. Hitherto the designs assumed one member of the crew would be a radio operator with telegraphy the primary means of communication, but radio-telephony facilities were included for short-distance working.

It seems now that telephony is becoming the primary system for all purposes with telegraphy taking second place and remote control is provided for operating the radio equipment from the pilot's cockpit. Direct operation is still a requirement so that the new sets have the dual facilities and provision is made for m.c.w. as well as c.w. transmission.

This requirement has led to considerable change in the design of h.f. aircraft equipment as more power output from the transmitter is needed to ensure satisfactory telephony communication over long distances and since frequent changing of frequency may be called for when working different ground stations and to enable the optimum frequency for the time of day and path to be selected a comprehensive remote control system must be included. Also the control unit must not be too bulky since space is at a premium in the pilot's cockpit.

In order to meet this growing demand Standard Telephones have produced a new version of their STR18B high-power h.f. telegraph-telephone aircraft communications equipment and in its modified form it is known as the STR18C. The main modification is the combining for general servicing purposes and convenience of the transmitter driver section and the receiver in a single unit. Some circuit modifications have been made also.

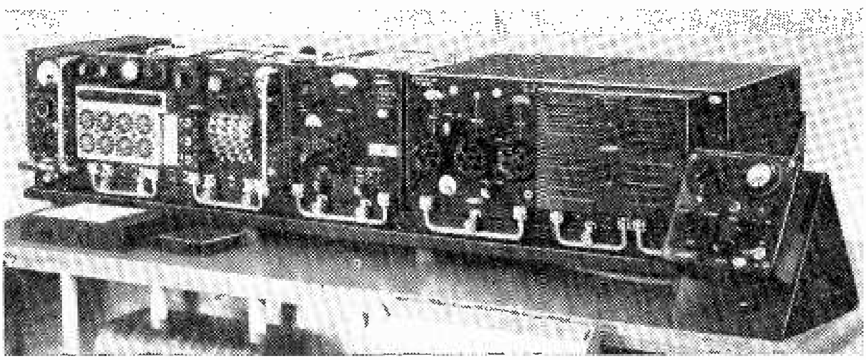
The STR18C allows for instant operation and selection from the remote control point of 100 channels in the band 2.8 to 18.1 Mc/s. All the channels are crystal controlled by separate crystals and each crystal is used for the receiver as well as for the transmitter which leads to some economy in crystals and space. The transmitter gives not less than 100 watts output on telephony throughout the band covered and provision is made for use of all orthodox wire or suppressed aerial.

Another high-power h.f. radio-telephone for aircraft with provision also for telegraphy operation on c.w. or m.c.w. is the Marconi AD107B. Full remote operation is possible and some 110 to 130 watts output is available on telephony for an open wire or suppressed aerial. Instant operation on any one of 20 pre-selected channels is possible and a new set of channels can easily and quickly be set up in flight should the necessity arise.

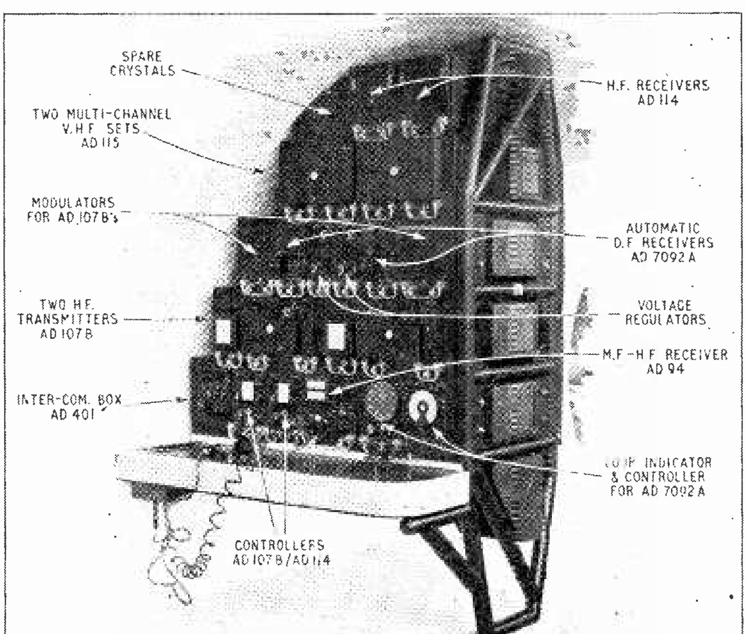
Whilst remote control may have certain advantages for aircraft operation it has undoubtedly added enormously to the complexity of the equipment. Admittedly the channels are precisely fixed by the use of crystals but the associated circuits in the transmitter and the receiver have to be tuned accurately on every change in frequency. Very small tolerances only are acceptable on the h.f. bands where receiver bandwidths must necessarily be restricted in order to avoid adjacent channel interference so that high precision in the whole of the remote control mechanism is absolutely essential.

Anti-Static Aerials

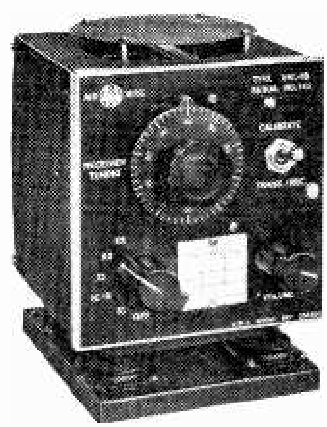
Prolonged tests have shown that with the new high-power h.f. radio-telephones ranges of 2,000 to 3,000 miles are normally attainable unless conditions are extremely bad. Atmospheric static especially in tropical regions is the main difficulty to long-range telephony operation on the high frequencies, but even this is apparently being overcome to a large extent by the use of the latest suppressed aerial systems. Apart from reducing drag and impeding the speed of the aircraft, which is one of the objections to exposed wire aerials, the suppressed or buried aerial appears to have a marked discrimination between static and signal with the result that when telephony is quite unintelligible on a trailing wire aerial it has often been perfectly understandable on the suppressed aerial. No adequate



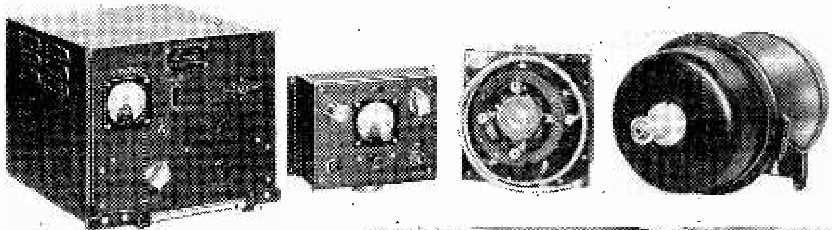
Among other equipment is shown the Standard Telephones STR18C high-power radio-telephone for remote control on the h.f. band.



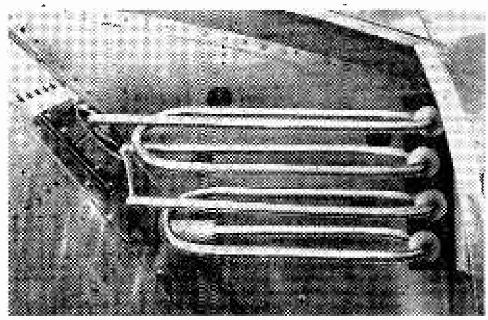
Complete Marconi radio installation for a modern air liner. Some equipments are duplicated to ensure no interruption in service in the event of a failure.



Amalgamated Wireless (Australia) "Air-Mite" v.h.f. aircraft equipment.



The various units comprising the suppressed aerial equipment made by Ekco.



explanation for this seems forthcoming but the system is still very new and few civil airliners have as yet been fitted. But some of the newer types will have it, the new Britannia being a case in point. So far the Royal Air Force have been the principal users.

The new h.f. equipments have somewhat obscured the developments in the v.h.f. part of the spectrum of which there have been a few although nothing of great consequence. The principal change is brought about by the likelihood that very shortly civil airliners will be required to operate on more than the former number of channels in the 118- to 132-Mc/s band.

It is expected that a minimum of 34 will be needed and to meet this possible demand Murphy has introduced a new remote controller for their TR41 v.h.f. aircraft sets giving instant selection of up to 36 crystal-controlled channels.

Compact, lightweight v.h.f. radio telephone sets find many applications in the smaller type of aircraft but in the majority of cases operation is required only on a very few channels. Murphy have control units for their sets giving a choice of few as well as many channels but one of the smallest sets for the facilities that it provides must surely be the Amalgamated Wireless of Australia "Air-Mite." This company is associated with the English Marconi Company.

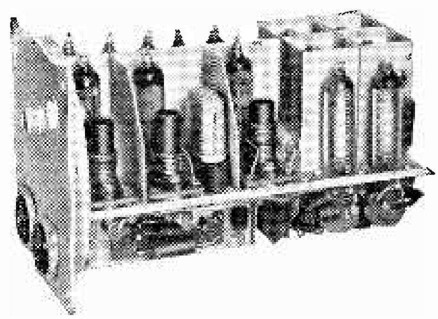
The "Air-Mite" measures $6\frac{1}{4} \times 4\frac{1}{2} \times 6$ in overall, weighs 12 lb and in its present form allows for operation on 3 crystal-controlled channels in the v.h.f. band and also provides intercom facilities between pilot and passenger. Its main usefulness is apparently found in aircraft employed on such prosaic functions as crop spraying, pipeline patrols in remote, sparsely populated country and also by flying clubs and private individuals. It now gives about twice the r.f. output than hitherto and ranges of 50 to 60 miles are said to be regularly obtainable at the usual flying heights of these aircraft.

Navaids

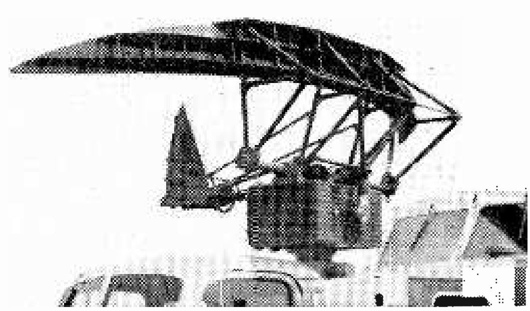
Among the new navigational aids is a simplified airfield approach radar working in the 3-cm band and produced by Decca from experience gained with marine radar on the same wavelength. Much of the marine technique and circuitry is embodied in the equipment which is known as the Decca Airfield Control Radar Type 424.

Its primary function is to speed up the landing of modern high-speed jet fighter aircraft but it needs only the addition of a v.h.f. radio telephone to convert it into a most useful small-scale GCA (Ground Control Approach) installation for airports where a full-scale GCA would not be justified.

Another equipment of a somewhat similar kind is made by E. K. Cole and details have already been given[1] of this Ekco Airfield Approach Aid, as it is called, in *Wireless World*. It has since been greatly improved in layout and in convenience in operation but basically remains the same.



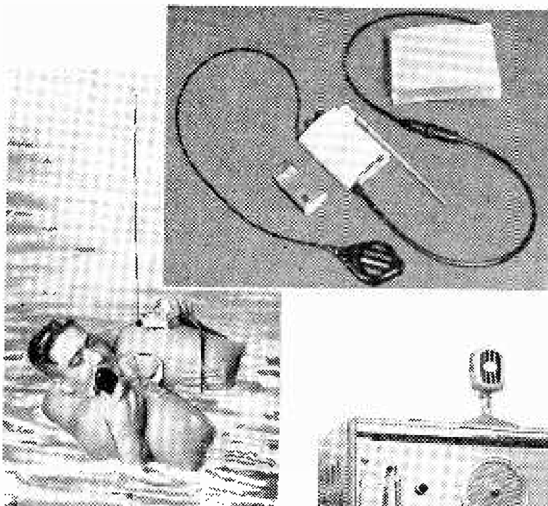
Murphy receiver used for radio control of model and target aircraft.



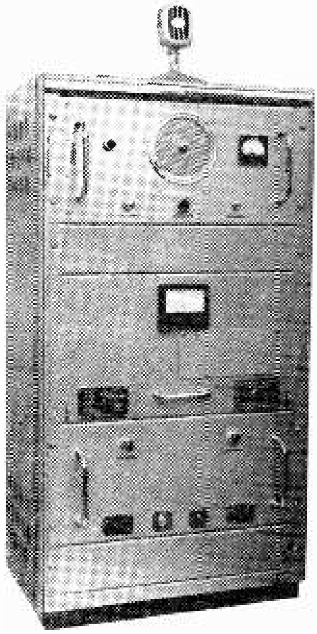
Scanner and radar head of the Decca Airfield Radar Type 424.

Radio equipment designed to hasten the rescue of survivors of aircraft wrecked in the sea has been receiving some attention lately. The subject has not been ignored by any means in the past but this year two entirely new sets, both in conception and make up,

[1] "Simplified Aerodrome Approach Aid," *Wireless World*, April, 1952, p. 162.



Burndept "Talbe" life-saving radio beacon with two-way R/T Its size can be judged from the box of matches.



Pye 50-watt v.h.f. transmitter-receiver (right).

make their appearance. One, the Ultra "Sarah," has already been described in some detail,[2] but the other, which is made by Burndept, made its début at Farnborough this year.

Known as "Talbe" it is a combined automatic radio beacon and short-range radio telephone set highly miniaturized and so designed that it can be stowed away conveniently in the standard type of life-saving jacket, familiarly known as a "Mae West."

With the aerial extended it automatically transmits a distress signal on 121.5 Mc/s using c.w. with a 1,000-c/s modulation pip once every 2 sec for identification. Location of the beacon in the sea is effected by the normal D/F technique adopted by Service aircraft which can pick up the beacon at about 50 miles when flying at 5,000 ft and the R/T has a range of approximately 20 miles. Small batteries weighing 2 lb suffice to operate the beacon for six hours continuously and give also an additional 30 minutes two-way telephony working.

Burndept has also developed a miniature life-saving beacon transmitter for use in collapsible dinghys on similar lines to "Talbe" but without the R/T facility. Having a larger battery, since weight restriction is not so vital, it has a duration of 24 hours continuous operation.

Radio control of models is not new, but it is likely to play quite an important part in the early design stages of new jet aircraft. Full-size prototypes of the larger swept-back wing or delta-wing aircraft are costly, whereas a study of the behaviour of a new design in model form with radio control is far less expensive and renders much valuable information.

[2] "Radio Rescue Beacon," *Wireless World*, August, 1953, p. 381.

Radio equipment based on the system described some time ago in *Wireless World*[3] is now being made by Murphy. It operates on 27 Mc/s but the same system is equally applicable to the 80-Mc/s band. Sub-carriers are used for each of the control functions required and the amount of movement in each case is determined by variations in the mark/space ratio. These are applied to the v.h.f. carrier by frequency modulation and servo mechanisms in the aircraft translate the radio intelligence into mechanical movement of the control surfaces.

Frequency modulation is used also in the radio-control equipment fitted to the target model aircraft made by M. L. Aviation. The system is to employ an auto-pilot and use the radio messages to over-ride the auto-pilot. Two-tone modulation conveys the control intelligence.

V.H.F. ground station equipment shows few basic changes but some new transmitters have appeared. Pye has one giving 50 watts output on any spot frequency in the band 60 to 184 Mc/s. Two models are made, one covers 60 to 100 Mc/s (PTC750), the other 100 to 184 Mc/s (PTC751). This firm has recently completed a mobile radio installation for a mobile GCI and operations room for the South African Air Force. It provides several different channels of operation with facilities for easy and rapid change in frequencies when required.

Many and diverse are the applications of tape recorders, but a novel one must surely be the Westinghouse Automatic Announcer. The basis of the equipment is a bank of small "cassettes," each containing a small spool of magnetic tape, another to wind it on and a three-purpose magnetic head for recording, erase and playback as required. Designed in the first place for train announcements, it is now being extended to announcing the arrival and departure of aircraft. Any number of small "cassettes" can be included in a single installation and each runs for 45 sec, but longer working times can be arranged if necessary.

[3] "Radio Controlled Jet Plane," *Wireless World*, December, 1952, p. 489.

RADIO EXHIBITORS AT THE S.B.A.C. SHOW

Amalgamated Wireless (Australia), Ltd., General Buildings, 99, Aldwych, London, W.C.2.
Burndept, Ltd., West St., Erith, Kent.
Ekco Electronics, Ltd., Southend-on-Sea, Essex.
Cossor Radar, Ltd., Highbury Grove, London, N.5.
Decca Navigator Co., Ltd., 1-3, Brixton Rd., London, S.W.9.
Elliott Bros. (London), Ltd., Century Works, Lewisham, London, S.E.13.
English Electric Co., Ltd., Queens House, Kingsway, London, W.C.2.
Ferranti, Ltd., Ferry Road, Crewe Toll, Edinburgh.
General Electric Co., Ltd., Magnet House, Kingsway, London, W.C.2.
Marconi's Wireless Telegraph Co., Ltd., Chelmsford, Essex.
McMichael Radio, Ltd., Wexham Rd., Slough, Bucks.
M. L. Aviation Co., Ltd., White Waltham Aerodrome, Maidenhead, Bucks.
Mullard, Ltd., Shaftesbury Ave., London, W.C.2.
Murphy Radio, Ltd., Welwyn Garden City, Herts.
Plessey Co., Ltd., Vicarage Lane, Ilford, Essex.
Pye, Ltd., Cambridge.
Redifon, Ltd., Broomhill Rd., London, S.W.18.
Salford Electrical Instruments, Ltd., Silk St., Salford, Lincs.
Sangamo Weston, Ltd., 22-26, Oxford St., London, W.C.1.
Standard Telephones & Cables, Ltd., Connaught House, Aldwych, London, W.C.2.
Ultra Electric, Ltd., Western Avenue, Acton, London, W.3.
Westinghouse Brake & Signal Co., Ltd., 82, York Way, King's Cross, London, N.1.

THE "BELLING-LEE" PAGE

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

A vivid working demonstration made possible by the clever application of a well known Radar Technique.

At the Radio Show, on the "Belling-Lee" stand was shown a normal television picture cut in half, each half showing a different condition. In the demonstration it simulated the difference, in a town like Bournemouth, of reception on a normal H type aerial, with that on a "Junior Multirod" with a masthead pre-amplifier. In practice the difference would be one of approximately 10 decibels, and the demonstration showed just what that would mean to the viewer in quality of picture, one half of which was impaired by the characteristic graining of the picture brought about by the use of excessive gain.

The same principle can be employed to provide an instantaneous

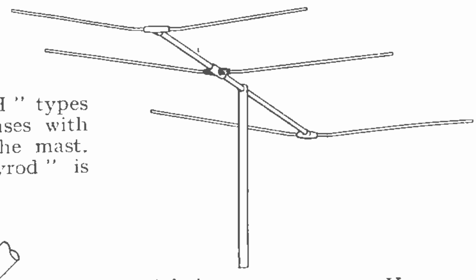
The illustration above shows a well known face with interference on one half of the picture and clear below.

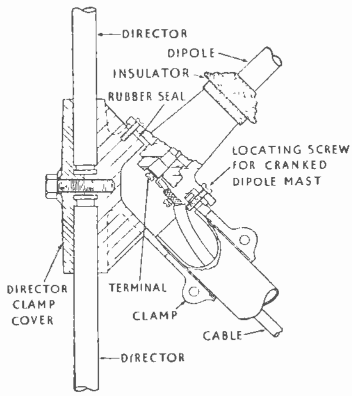
comparison of two aerials, either straightforward or for correct orientation, or for the rejection of interference.

Many "Wireless World" readers will be well aware of how this is done, but for the benefit of the others, we would say that we employ a picture splitting unit combining two input signals and feeding to a common receiver. The two inputs are connected to two separate single valve amplifiers which are made inoperative alternately by the injection of a square wave signal on to the suppressor grids. The switching waveform is synchronized to the frame frequency. It will be understood that the half frame be so arranged as to be top or bottom or in the middle, as a band with a quarter frame above and below.

The New "Kayrod"

The "Kayrod" is the most ingenious medium range aerial yet offered to the public. Technically it is better than some "H" types we have seen. It dispenses with both the crossarm and the mast. The heart of the "Kayrod" is





the centre casting and insulator combining the features of the reflector casting illustrated above. The inclusion of the ratchet bracket makes this aerial very easy and cheap to instal. The "Kayrod" is an additional useful weapon in the war against multiple images, but that doesn't mean that we claim it to be a "ghostmaster." The characteristics are such that it is good, but there will be many cases where the "Junior H" will give as good or better picture and still more cases where the "Junior Multirod" will be the answer.

Screening of a T.V. Aerial

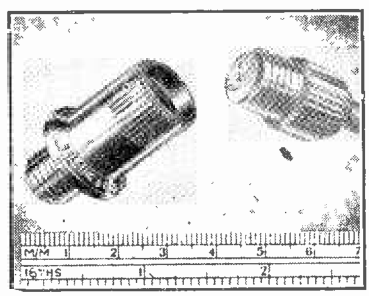
We are often asked if it is practical to connect a wire mesh or netting screen say $\frac{1}{4}\lambda$ from the element of a T.V. aerial, between the aerial and some source of interference such as a busy road. The sensible answer is no. If you have to erect a T.V. aerial on a fairly high building that has a zinc roof, you may get rid of severe motor interference by setting the aerial well back, but in this case the screen is very large compared with the aerial and casts a wide shadow as it were.

Horizontal Aerials with an Uplift

If a dipole or reflector tube of reasonable dimensions is held horizontally by one end, the free end will droop, and to us a drooping aerial is an eyesore. You can increase the diameter and gauge of metal to uneconomical figures without gaining much. We therefore tried to put a "set" in the element so that its "droop" would bring it horizontal. From this thought we uplifted the element considerably, and now all "Belling-Lee" horizontal aerials are instantly recognised by this upswept feature. They are exceedingly well known around Newcastle and Belfast.

Thank you Goodwood

At the time of writing this article we understood that all cars that were entered for the international nine hour race at Goodwood held on Saturday, 22nd August, must be fitted with ignition suppressors. Television reception at St. Mary's Institution



"Belling-Lee" "Sparkmaster"—Ignition Suppressor 2/6.

situated near the track has apparently been severely interrupted by previous racing, and the Duke of Richmond, owner of Goodwood and President of the British Automobile Racing Club has decided to make suppression a condition of entry. This is a wonderful example to the general public, many of whom still seem to fear that the performance of their cars will be impaired.

Written 27th August, 1953.

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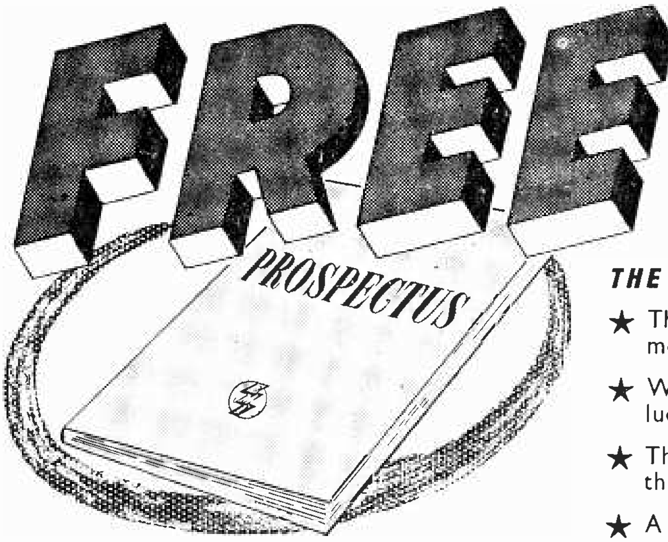

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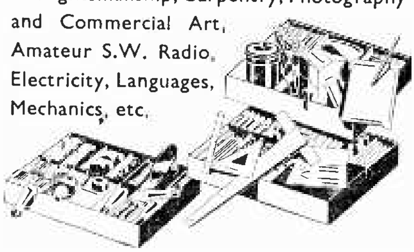

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SUBJECT(S) OF INTEREST ....

IC18

LETTERS TO THE EDITOR

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

Allocation of Frequencies

YOUR August Editorial rightly expresses misgivings on the subject of v.h.f. frequency allocations in this country, particularly on the potential clash of television on the one hand, and Government and mobile services on the other. I should like to comment on a particular aspect of this problem.

Your issue also contained a description of the newly developed air-sea rescue equipment SARAH, and indicated that it operated just over 200 Mc/s. I have nothing but support for efforts made towards introducing satisfactory air-sea rescue communication, but for this particular equipment to be of value the following conditions will have to be met:

(1) It will have to operate on a frequency above Band 3 (216 Mc/s) and the upward extension of it being planned in Europe. If it does not, the airborne receiver will be jammed at very great ranges by television transmitters, British or Continental, or both.

(2) The frequency band allotted to it will have to be available eventually for both civil and military users.

(3) At least a measure of international agreement will have to be obtained on the channels to be used, and upon the rules covering its operation.

I hope some reassurance on these points will be forthcoming, otherwise the designers of the equipment may suffer in the way your Editorial foreshadows. If clear public statements of intention were made by the Government on frequency allocation, this kind of situation need not arise.

My view is that there is an urgent need for v.h.f. air-sea rescue arrangements and that these could be most easily made on the international air distress frequency in the 120-Mc/s band, or on the international marine frequency of 156.8 Mc/s, or on some nearby channel. On these frequencies a minimum of new equipment will be required.

Rees Mace Marine, Ltd. R. I. T. FALKNER.

Exhibitions and Catalogues

THE excessive number of exhibitions of electronic equipment means that the same manufacturers re-exhibit the same products on every occasion; thus their stands are overwhelmed with equipment which is already much too familiar.

An exhibition stand should focus the attention on one or two new exhibits only, and these should be accurately described in the technical leaflets available.

These leaflets and also the exhibition catalogue are all too often so written that they are of little value. A visitor wishes to know the technical details of the exhibits in terms he can understand; a bald statement of the name of the equipment is useless. The leaflets supplied are often couched in the florid terms of a press handout.

A catalogue should enable a visitor to decide in advance which stands he wishes to visit and later to refresh his memory on the technical details of the equipment seen. But, unfortunately, this is not often the case. In a recent catalogue, out of a total of 142 pages only 43 are given to the description of the exhibits and 15 to a classified index; the description of the products of three manufacturers is crammed into a single page and this allows only the name of each exhibit to be given. Although this is not the worst example which I have seen, it cannot be said to perform the required functions as described above.

Surely, it is not asking too much of manufacturers and stand designers to give prominence to really new equipment and to provide an accurate technical description of it. If, therefore, manufacturers, stand designers and exhibition organizers would collaborate now, next year's exhibitions may prove to be of a higher standard.

Hayes, Middx. S. PEARCE.

Ignition Interference in U.S.A.

FOR many years I have been reading the random writings of "Diallist" with interest and some amusement, but I fear that I really must protest against his proposal to penalize millions of motorists in order to permit British manufacturers to continue to turn out poorly designed television sets that are subject to interference from automobile ignition. Here in the U.S.A. our television sets operate in the midst of millions of motor cars, all unsuppressed, yet never have I seen a case of ignition interference or even heard of anyone troubled by it.

Rockville, Md., U.S.A. MALCOLM S. MORSE.

Dry Cells

I WOULD like the opportunity of dispelling some of the doubts as to the reliability of the present type of dry cell which may have been aroused by R. W. Hallows' article in your June issue.

In the first place the idea of using cumbersome designs by which the electrodes are reversed is by no means new as a study of the patent and technological literature will show. These ideas have not received wide acceptance, as the present design of using the zinc can as both container and electrode is fundamentally correct and lends itself to very fast and economic processing.

Ways and means of overcoming zinc corrosion and early perforation have been studied extensively by battery technologists, particularly during the last war when the demand for primary cells and batteries capable of storage and operation under varied climatic conditions was of extreme importance. A fair measure of success has been achieved by chemical methods and careful, controlled processing. It is fair to say that, nowadays, commercial types of h.t. batteries will store for 12 months, and most torch type cells for 2 years, without undue loss in capacity or reliability.

Major Hallows' conception of the electrode reactions is also somewhat off the beam, and this to some extent leads him to be a too earnest advocate of the "inside-out cell." The reduction in size of the zinc electrode can be carried too far, with the result that it can suffer from lack of electrolyte at high current densities—this factor alone restricts the application of this type of cell. Furthermore, the mere placing of the electrode inside the cell does not overcome the consumption of electrolyte, whilst the cell is idle, at the electrode face, and the consequent inefficiency due to deposition of water-insoluble compounds.

His view that, by extending the carbon area, the efficiency of the manganese dioxide electrode is increased is also not true. He has been led into this belief through his conception that carbon is the electrode and the manganese dioxide is packed around it to keep it clear of hydrogen. In fact, it is the manganese dioxide which is the electrode, and the oxidation of hydrogen takes place at the oxide surface. The oxide is intimately mixed with some form of carbon, and this, with the carbon rod, acts mainly as a conductor. One can see, therefore, that the carbon area is already quite large. The main point in disposing this electrode around a cylinder should be to lessen its thickness so that the conductivity of the electrode is not unduly lessened by the end products of the electrode reaction; i.e., lower oxides of manganese and zinc amino compounds. The design suggested does not do this.

Battery technologists are not unmindful of the present deficiencies in the current design of cell, nor of the necessity of saving zinc, and constant research is in progress to find a substitute (e.g., magnesium), as well as to prevent wasteful corrosion of zinc itself.

R. W. LEWIS
(Chief Chemist, Vidor, Ltd.).
South Shields, Co. Durham.

R. W. HALLOWS writes: My friend R. W. Lewis is so knowledgeable about dry cells that I should hesitate to cross swords with him, had he not made a lunge at me.

Despite what he writes, the "inside-out" cell has proved successful in the United States and I understand that it is shortly to make its appearance here.

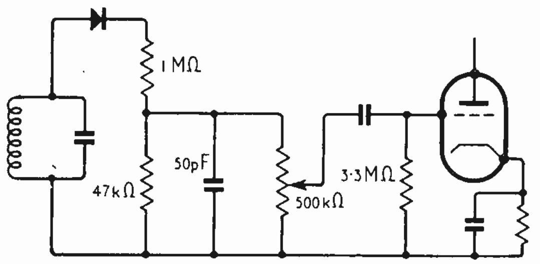
I did not suggest that the shelf-life of our cells is poor; what I did (and do) complain of is that too many of them perforate while in use when their e.m.f.s are considerably above 0.9 V. One cell which passes out in this way can render the other 79 of a 120-V h.t.b. useless.

Pace Mr. Lewis, I really do know that the cathode of a Leclanché cell is not the carbon rod, but what I called in these articles the manganese-dioxide element. I agree that during discharge oxidation of hydrogen occurs mainly at the oxide surface; in this way hydrogen is prevented from collecting as densely as otherwise it would on the particles of carbon in the depolariser mix and on the central conducting rod.

No known depolariser, however, is sufficiently active to prevent entirely the accumulation of hydrogen. Some does collect, with the result that internal resistance rises and e.m.f. falls.

Broadcast Transmitter Distortion

IN reply to J. D. Herring (September issue) the detector circuit of my receiver is as shown. The figure I gave was calculated for 5,000 c/s. Admittedly, I ignored both stray capacitances and component tolerances. But does this matter? I chiefly meant to convey that the ratio is



about as near to unity as one can, in practice, reach. In fact, it is doubtful whether high-level modulation will occur at a frequency of 5,000 c/s. This detector circuit, and others more modest, give complete satisfaction on a *good* transmission, even where the dynamic range covered is extremely wide.

London, N.10. IAN LESLIE.

Correction.—In the letter from J. D. Herring on p. 416 of our September issue the lower of the two resistors forming the diode load should have been marked 47 kΩ.

Technical Qualifications

I RECENTLY attended a post-graduate course in electronics at the English university (special honours degree standard) and, in general, found that holders of the City and Guilds Full Technological Certificate in Telecommunications tended to be weak in mathematics.

To qualify for the Final and Full Technological Certificate the standard of mathematics is approximately Inter. B.Sc. level. Endorsements in mathematics can be obtained by taking Grades 4 and 5 and the standard then approaches that of a general degree, but at present such endorsements are *optional*.

The present City and Guilds syllabus places too great an emphasis on telecommunications as understood by Post Office engineers.

The electronic industry of to-day calls for engineers with a knowledge of pulse techniques (radar, television and computors) and microwave circuitry.

My main criticism of the City and Guilds examinations is that there are too many "talkie-talkie" examination questions and too few simple practical design problems. No engineer worthy of his name can afford to be without a working knowledge of elementary physics, some mechanics and drawing.

The letter from "Personnel Manager" (September issue) prompts me to ask why membership of the Brit.I.R.E. is considered inadequate as a condition for enrolment by the Technical and Scientific Register. Apparently a radio engineer can only obtain "official" recognition if he is first trained as an *electrical* engineer! Surely if public corporations, such as the B.B.C., accept Brit.I.R.E. membership as a means of obtaining engineer status, the Technical and Scientific Register should give similar recognition.

Ruislip Manor, Middx. M. L. BARTON.

THE City and Guilds of London Institute Full Technological Certificate in Telecommunications is a qualification recognized by the Admiralty Scientific Service and the Ministry of Supply for the post of Experimental Officer. The Ministry of Education regard its holders as qualified teachers of that subject. Also the B.B.C. advertise that those who possess it are eligible for posts as Grade C engineers. Industry probably fails to appreciate its worth because of the incomprehensible attitude of the Technical and Scientific Register which, whilst recognizing a Higher National Certificate, regards those persons who hold City and Guilds qualifications as being of craftsmen status only. This attitude is deplored by most responsible educationalists, but it must affect the attitude of industry towards this qualification.

Sully, S. Wales. TERENCE L. SQUIRES.

"*Wireless Fifty Years Ago*"

MAURICE CHILD'S notes in your August issue evoke many pleasant memories—some of them of Maurice Child. They also move me to make some comments which may have some interest even if they are not very relevant. For example, his reference to the early Marconi aerial, supported by a nearly vertical bamboo sprit, makes me wonder why the present sail arrangement of most American—and maybe British—yachts is called "Marconi Rig," for that rig employs no sprit or gaff.

I am sure that, had space permitted, Mr. Child would have liked to have said much more of those early days, otherwise he would have mentioned the ever-kindly and courteous Commander Loring, who personally inspected all new wireless installations. When I fitted a ship I would wire him and he would promptly come down and inspect the installation wherever it might be.

Mr. Child's reference to the early detectors seems to me to under-emphasize the importance of carborundum, which was the preferred detector in commercial practice until the advent of de Forest's triode. It was, in fact, employed in the Marconi wavemeter shown in Mr. Child's illustration. Operators often carried their own, which they used when carborundum was not supplied.

I had frequent recourse to Mr. Child's school when I was in need of operating talent over forty years ago, and I am delighted to know that he still carries on the good work.

New York, U.S.A. ARTHUR H. MORSE.

Push-Pull Transistor Amplifiers

By J. I. MISSEN,* B.Sc., A.R.C.S.

Practical Circuit Giving an Output of 400 mW with Point Transistors

THE use of duality in deriving transistor circuits from vacuum tube circuits was explained in the September issue of this journal in Part 8 of the series dealing with transistors. A brief mention was made of the transistor dual of the Class B thermionic valve amplifier, and a theoretical circuit for a power amplifier was given. The essentials of this circuit are reproduced in Fig. 1.

A practical point-contact transistor push-pull amplifier which has been developed from the circuit of Fig. 1 is capable of providing over 400 mW of a.f. power into a suitable load at under 10 per cent harmonic distortion. The driving power is within the capabilities of a single transistor stage.

Limitations of a Conventional Transistor Amplifier.—Before proceeding to a description of the actual circuit, it is worth while considering the reasons why a single transistor power amplifier of conventional design is not capable of delivering more than 20 mW of output power.

Typical static characteristics for the transistor are shown in Fig. 2. Collector current is plotted against collector voltage for various emitter currents. No appreciable control over collector current is exercised by negative voltages or currents at the emitter. The minimum collector current for a given collector voltage is therefore determined by zero emitter current.

The power developed in a given collector load resistor is obtained by drawing a load line of slope equal to the load resistance from a given h.t. voltage point on the collector-voltage axis. The power output is then :—

$$\frac{(V_1 - V_2)(I_2 - I_1)}{(2\sqrt{2})^2} \quad \text{.. (1)}$$

where $(V_1 - V_2)$ and $(I_2 - I_1)$ are the peak-to-peak collector voltage and current swings and the factor $\left(\frac{1}{2\sqrt{2}}\right)^2$ converts to r.m.s values.

The electrical characteristics of a transistor deteriorate with rise of temperature, so that the collector dissipation rating is limited, in most designs to 100 mW or less.

Now the dotted curve of Fig. 2 represents the maximum permitted collector dissipation, i.e. for every point on the curve, V_cI_c = 100 mW. Thus the operating point must never lie outside the area between the curve and the voltage and current axes. In the example chosen, the load line for an h.t. of 50 volts has been drawn tangential to the curve of maximum permitted dissipation so that the collector dissipation reaches its maximum rating at one point in the cycle.

With this value (6.25kΩ) of load resistance, the collector dissipation at point A, corresponding to zero emitter current, is 88 mW. By utilising expression (1), the power output is found to be 20 mW.

It will be noted that the collector dissipation for

* Research Laboratories General Electric Co. Ltd.

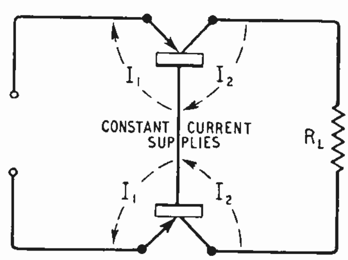


Fig. 1. Transistor dual of a Class B push-pull amplifier.

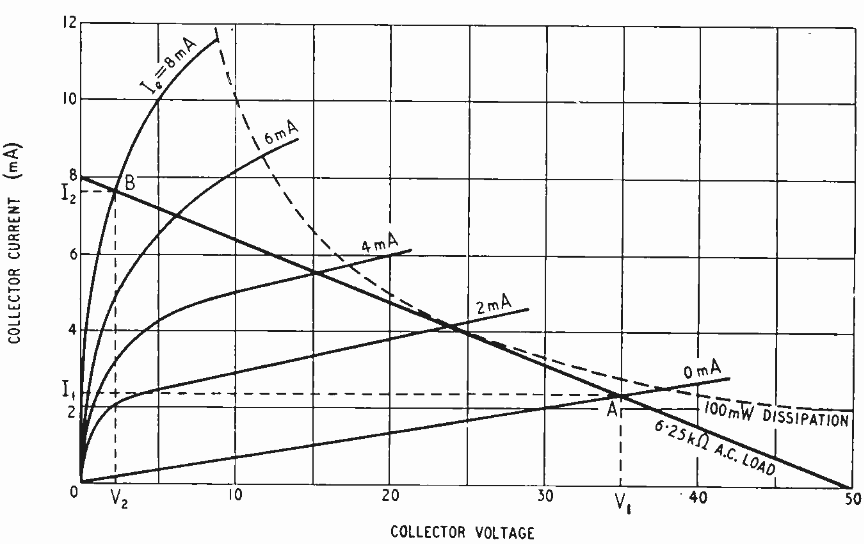


Fig. 2. Collector current/collector voltage characteristics of a point transistor.

the quiescent condition, defined by zero emitter current, is approaching the maximum permitted value.

Thus, to summarise, the power output from a point transistor used in the type of circuit peculiar to thermionic valves results in a power output limited to some 20 mW by virtue of the h.t. and load limitations imposed by the low collector dissipation rating. Furthermore, at the nominal quiescent condition of 88 mW collector dissipation, only a small change in h.t., ambient temperature, or transistor equivalent circuit parameters could result in the collector dissipation exceeding 100 mW, with disastrous results !

Requirements for Higher Output Power.—A new approach is needed if the transistor is to prove useful as a power amplifier which will provide a reasonable ratio of power output to collector dissipation.

The two main requirements are :

(a) A system of operation providing low collector dissipation in the quiescent condition, which will allow the use of a higher supply voltage.

(b) A type of power supply with "poor" regulation so that the quiescent collector dissipation is maintained well within the maximum rating.

If, instead of operating with zero bias, the emitter is given a large positive bias, then with a resistive collector load, the quiescent point would be B (Fig. 2), where the collector voltage is low, and the collector current relatively high. Under these conditions the collector dissipation is only 22 mW, which is a quarter of the dissipation when the transistor is used in a conventional circuit. Thus condition (a) is satisfied. Requirement (b) can be met by arranging that the resistive collector feed is of such value that the load line of Fig. 2 does not cut the curve of maximum permitted dissipation.

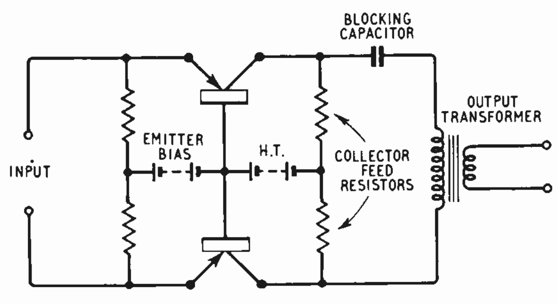


Fig. 3. Modified transistor push-pull output stage with positive emitter bias and output transformer in parallel with the high-value collector feed resistors.

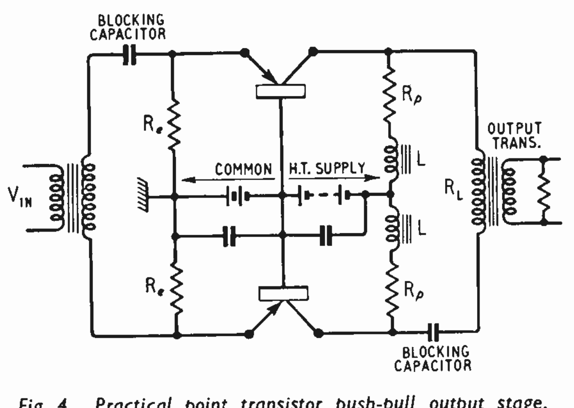


Fig. 4. Practical point transistor push-pull output stage. Typical component values are given in the text.

However, in an a.f. output stage feeding a loudspeaker, an output transformer is required for matching to the low-impedance speaker. Now as requirement (b) necessitates collector feed resistors of high value, it becomes more efficient to run the output transformer in parallel with these resistors.

Combining these features, it is possible to evolve a modified push-pull output circuit for transistors in which the emitters are biased positively and the collectors are fed from a source of high internal impedance, thus permitting a much larger voltage and current swing at the collectors for a given dissipation. A simple circuit incorporating the above ideas is shown in Fig. 3.

Equivalence Between Theoretical Dual and Practical Circuits.—In Fig. 1 the constant-current supplies are indicated by dotted lines. Probably the simplest method for producing a current of constant value, irrespective of the termination, relies on a high voltage source E, in series with a high resistance R. If the circuit is completed by a resistance r ($\ll$R) then

$$I = \frac{E}{R + r} \simeq \frac{E}{R} = \text{constant} \quad .. \quad .. \quad (2)$$

It will be seen that the power supply to the collectors and emitters of the circuit of Fig. 3 is virtually a constant-current supply. In general, a compromise must be effected in the values of E and R from the standpoint of power economy.

From a comparison of the circuits of Figs. 1 and 3 it is obvious that there are striking similarities, even to the parallel load. Thus in the case of the transistor push-pull amplifier, a circuit development on the basis of obtaining high power output with low collector dissipation leads to the same result as would be obtained by deriving the dual of the Class B thermionic valve amplifier circuit.

Circuit Details.—The complete circuit arrangement is shown in Fig. 4 and may be seen to be a development of Figs. 1 and 3. The constant-current supply for each collector consists of a battery in series with an inductance L and a resistance R_p, the battery being common to the two. The use of an inductance enables a lower battery voltage to be used than with a resistance alone : also it makes the a.c. impedance of the source high to audio frequency, so that its shunting effect on the load is less. Typical values for L and R_p are 20H and 2.2kΩ respectively.

The bias current to the emitters is obtained from a battery in series with resistors R_e. A typical value for R_e is 1,000 Ω.

A single battery is used for both collector and emitter. This is earthed at the positive end, and a tap corresponding to the emitter bias is connected to the base leads of the triodes. Thus the same battery may be used for the h.t. supply of preceding stages when necessary. Usual values for the battery would be − 45V with base tap at − 3V.

The output transformer is connected between the collectors via a blocking capacitor of value 1 μF and is arranged to match from 5000 Ω to 15 Ω. The input transformer feeds the emitters via a 2-μF blocking capacitor. Two G.E.C. point-contact transistors, type G.E.T.1, were used.

Operation of the Circuit.—The operation of a thermionic valve push-pull amplifier is usually analysed graphically. In this method the anode current/anode voltage characteristics of the two valves are combined on a common voltage axis, and both are symmetrically disposed with respect to the quiescent anode voltage. The load line is then superimposed on the two families of characteristics.

A similar procedure can be applied to transistors, but by virtue of the dual relationship between the "crystal triode" and the thermionic triode. The common axis is collector current.

The combined characteristics are shown in Fig. 5. In the example taken the quiescent current is taken as approximately 10 mA in each transistor, which is obtained when the emitter is biased to a current of approximately 10 mA. The collector dissipation of each transistor in the quiescent condition is approximately 20 milliwatts.

The d.c. conditions are determined by the value of the h.t. voltage and the resistances R_p, while the a.c. load is approximately R_L, if the shunting effect of the constant current network is small. Thus both d.c. and a.c. load lines are required to determine the operating conditions and power output from the curves of Fig. 5. The d.c. load line is drawn through the quiescent point of Fig. 5, to meet the voltage axis at a point corresponding to the battery voltage. The slope of the load line gives the value of the d.c. load. The a.c. load line similarly passes through the quiescent point. In Fig. 5 two a.c. load lines have been drawn, corresponding to R_L greater or less than R_p.

For the case of R_L greater than R_p, the peak voltage appearing between collector and base (V′) exceeds the battery voltage, due to the back e.m.f. appearing across the inductance L in series with the battery e.m.f.

The peak-to-peak voltage appearing across R_L is thus 2V′, and the power output is

$$P_{out} = \frac{(2V')^2}{8R_L} = \frac{(I' - I'')^2 R_L}{8} \quad .. \quad .. \quad (3)$$

The conditions prevailing during one half cycle of operation are indicated in Figs. 6 and 7. Suppose each transistor to be drawing a quiescent emitter and collector current of I_e and I_c respectively. If a sinusoidal input signal I_e . sin ωt is applied between the emitters, the emitter currents will be modified accordingly. Given a peak input current swing equal

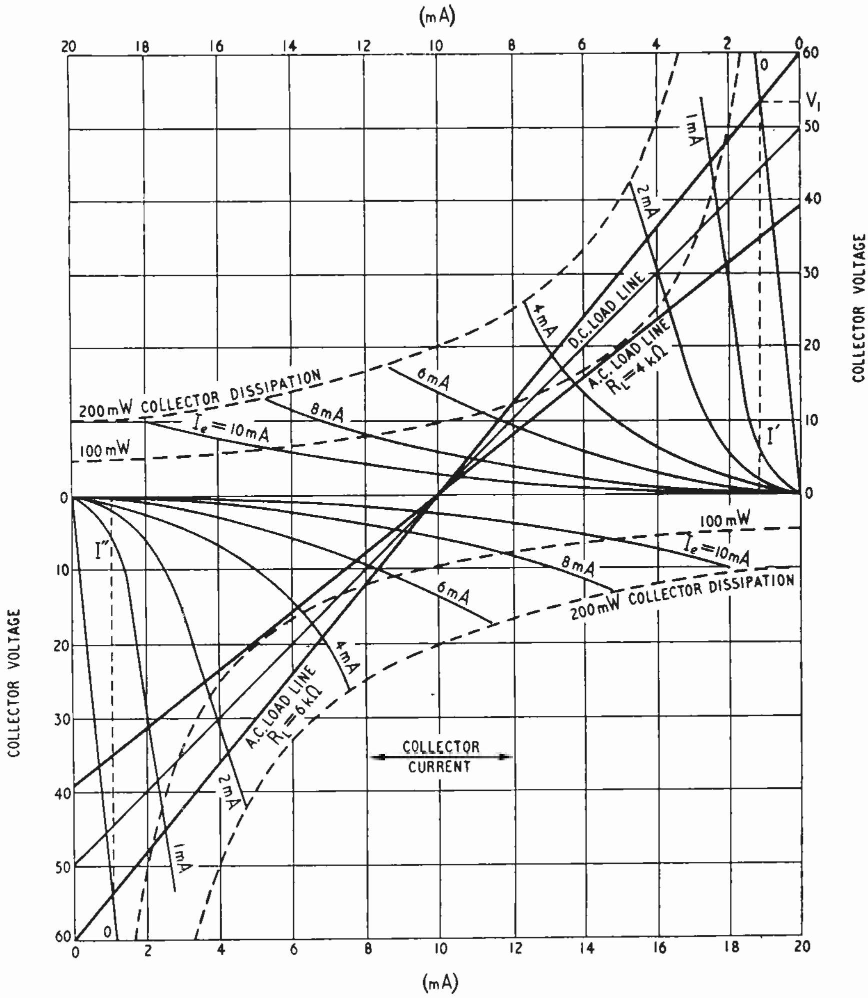
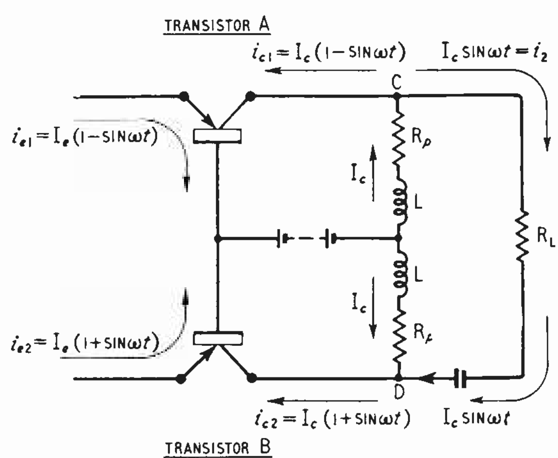


Fig. 5. Combined characteristics of two type G.E.T.I. transistors in push-pull.

Fig. 6. Paths followed by current during one half cycle of a sine wave.



to the steady emitter bias, then, on the negative half cycle, the emitter current of transistor A in Fig. 6 will swing to zero according to the relation $i_e = I_e (1 - \sin \omega t)$, for ωt between o and π.

Assuming that distortion may be neglected, the collector waveform in transistor A will be indicated approximately by the relation $i_{c1} = I_c (1 - \sin \omega t)$ as in Fig. 7. However, the collector current is supplied from a network which presents a high impedance to a.c. and maintains a constant current I_c. Thus the a.c. component of I_c is negligible, so that on equating the currents at the junction C shown in Fig. 6, $I_c = i_{c1} + i_2$, and on substituting for i_{c1}, $i_2 = I_c \sin \omega t$, which is a half sine wave positive pulse of current, which passes through the load R_L.

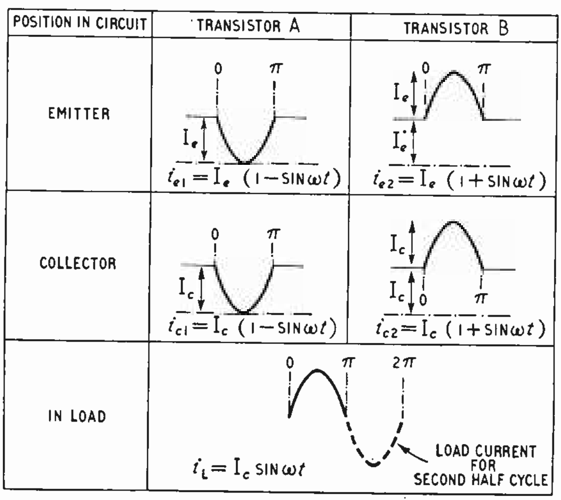
At the lower transistor B the standing emitter bias will be increased by the positive-going signal, so that the collector impedance will be very low and will present very little impedance to the load current $I_c \sin \omega t$.

For the next half cycle, where ωt lies between π and 2π, conditions will be reversed, with transistor B biased to a high-impedance condition. A current pulse is thus driven through the load in the reverse direction, and back through transistor A, which is then in a low-impedance condition.

To summarise: the effect is that each triode is biased to a high-impedance condition in turn, so that as the collector current falls, a current flows through the load such that the instantaneous sum of collector and load currents over a half cycle is constant and equal to the current supplied by the constant-current network. The resultant current waveform through the load over a complete cycle is sinusoidal and has a peak-to-peak amplitude of approxiamtely $2I_c$.

In this push-pull amplifier the idle transistor is biased to a low impedance which is in series with the load, whereas in a thermionic valve push-pull circuit the idle valve is biased to a very high impedance, which is effectively in parallel with the load.

Fig. 7. Waveforms of current under the conditions of Fig. 6.



Experimental Results.—In general, the operating conditions and power output which were indicated graphically in Fig. 5, were obtained experimentally; allowance being made for the small amount of power dissipated in the idle transistor which is in series with the load. The power output was calculated from measurements of the voltage swing across a resistor which replaced the output transformer. For applications where a distorted waveform was acceptable, an output of over 0.5 watts was obtainable.

It will be observed from Fig. 5 that the upper a.c. load line passes through a region of the graph in which the collector dissipation exceeds 100 mW, i.e. outside the area enclosed by the 100 mW curve and the axes. However, during that part of the cycle for which the triode emitter is biased positively, the collector dissipation is approximately equal to that under quiescent conditions, and is considerably less than 100 mW, so that the mean collector dissipation is under 100 mW although the peak dissipation exceeds this value.

Experimental results over a number of hours, during which time the peak dissipation exceeded 100 mW for a small fraction of each cycle, have shown no deleterious effects on the germanium triodes.

Performance figures for the transistor push-pull amplifier are given in Table I. The first set of results gives the maximum power output obtainable without exceeding the mean collector dissipation rating, or allowing the harmonic distortion to exceed 10 per cent. Under these conditions the power output amounted to 420 milliwatts in a 5,000-Ω load.

The second set of results was obtained under conditions for which the collector dissipation never exceeded 100 mW, and the power output was then 200 mW. This operating condition, for which the a.c. load line is tangential to the 100 mW dissipation curve, is illustrated on Fig. 5.

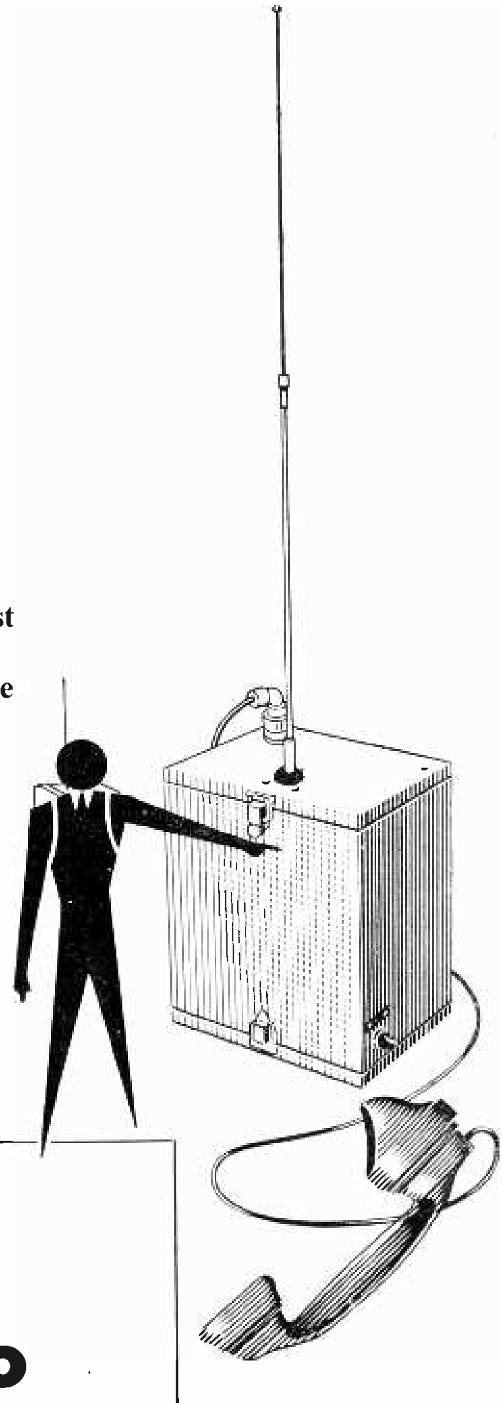
It will be seen from Table I that the overall efficiency is lower than might be expected. This is due to the power dissipated in the collector feed resistors R_p.

Similar precautions with regard to bias are required as for a Class B thermionic valve circuit, in that h.t. must be switched off before the bias is removed. Failure to do so results in the collector dissipation rating being exceeded, with consequent failure of the transistor.

The circuit has been found to operate satisfactorily over a considerable period of time and has been successfully applied to an all-transistor superheterodyne broadcast receiver and an a.f. amplifier.

TABLE 1

Battery Voltage	Mean Collector Dissipation (Milliwatts)	Peak Collector Dissipation (Milliwatts)	Power Gain (db)	Efficiency (Per cent)	Harmonic Distortion (Per cent)	Power Output (Milliwatts)
50	100	150	12	28	10	420
35	65	100	13.5	21.5	9	200



German Radio Show

An Engineer's Impressions of the Dusseldorf Exhibition

By J. E. COPE*

THE German radio exhibition this year was evidently modelled on our own Show, although the physical layout was rather different because it was held in several halls, each of which was somewhat smaller than Earls Court. Nevertheless, it included a large television studio with a public gallery, and programmes were transmitted from here to the various receivers in the exhibition. The cameras were operated from an O.B. van which had been driven into the studio, while a second van provided programmes from a nearby theatre. In another hall was the "Fernsehstrasse"—the equivalent of the Earls Court "Television Avenue." The quality of the pictures shown here was good, but in spite of the use of 625 lines, as against our 405, it was not on the average as good as that to be seen in our own "Television Avenue."

My greatest single impression was of the high quality reproduction of the average German radio set—and the fact that the public is prepared to pay for it. Table models often have two low-frequency loudspeakers and one tweeter. Many different makes of tweeters are available and several are of the electrostatic type. On the Grundig stand, a great deal of attention was attracted by an elaborate radiogram/tape-recorder combination which had no fewer than eight loudspeakers! There is evidently big business in tape recorders, and this, together with f.m. broadcasting and the recent introduction of the long-playing record, probably accounts for the great public interest in "hi-fi."

Internal Aerials

With 108 f.m. stations now operating in Western Germany, there was naturally a large number of f.m. sets on show. Most of these were combination models with long, medium and short a.m. wavebands, and they all had internal aerials, including dipoles for the f.m., as well as facilities for external aerials. Many of the receivers used a ferrite rod aerial which could be rotated by a knob outside the cabinet to reduce interference to a minimum.

There is as yet no large-scale production of television sets in Germany and the receivers shown were generally pre-production models. However, public interest was high and there is no doubt that production will mount rapidly during the next twelve months. Many of the cathode-ray tubes were either American types or made from American glass parts, but the German production of 14-in and 17-in tubes is well under way. There was no evidence that any larger tubes are likely to be made in the next twelve months. Quite a number of 21-in sets were on show, but all of these had American tubes in them. The cheapest receiver I saw was priced at 800 marks, but it had no sound, and in order to use it one had to buy from the same company an f.m. set covering the television sound band.

Practically all the television receivers have 12-channel tuners, mostly copies of the American turret tuners, with at least one Oak-type switch and one eddy-current inductance tuner. The circuitry, too, tends to follow American practice, especially with things like inter-carrier sound and vision a.g.c. Many sets, however, use the a.c./d.c. series-heater techniques, as valve types are more like the British than the American—in some cases they are identical.

The American influence was also to be seen in the cameras used in the television studio, which contained American image orthicon tubes. These cameras, made by Fernseh G.m.b.H., have five-lens turrets, and focusing is achieved by moving both the turret and the tube, thereby eliminating the need for a counterweight. Critical adjustment of light intensity is obtained by the use of a variable density filter, the lens iris being set to the required depth of focus. This firm also showed an industrial television equipment using a small super-iconoscope camera, while Grundig had a similar apparatus using a photo-conductive type of pick-up tube.

Good Components

Components generally seemed to be of good quality and well designed, and in general were similar to those produced here and in America. Both germanium diodes and transistors are available, though the last mentioned only in small quantities, at prices between £1 and 30s apiece. Aerials of all shapes and sizes were on show, and they seemed to me to very cheap compared with ours. A television signal generator made by Telefunken that I happened to see struck me as being much more versatile than anything we have over here. Besides producing a variety of different waveforms, it included a wobbulator and covered eleven television channels and two i.f. frequencies. In fact, it took about a quarter of an hour for the man on the stand to demonstrate the full capabilities of the instrument to me.

The German Post Office had a big exhibit and I was particularly impressed by their demonstration of the effect of various types of interference on sound and television receivers.

* Pye. Ltd.

PUBLICATION DATE

We regret that owing to a temporary re-arrangement at our printers it will be necessary to postpone publication of the November issue of *Wireless World* from October 27th until November 3rd.

WORLD OF WIRELESS

Radio Servicing Certificate ✦ "Electronics": Official Ruling? ✦ European V.H.F. Stations ✦ Personalia

Servicing Exams

NEW REGULATIONS have been introduced by the Radio Trades Examination Board for entry to the Radio Servicing Certificate examination which is conducted jointly by the R.T.E.B. and the City & Guilds.

The change reduces from five years to three years the minimum time which entrants must have spent in gainful full-time occupation in radio engineering or servicing and the age of entry from 21 to 19 years. The certificate, however, will not be issued until the candidate is 21. Entrants who have completed an approved course of technical instruction will in future have to serve only one year's full-time servicing instead of three years.

These regulations will apply to the 1954 examination which will be held on May 4th and 6th for the written papers and May 15th for the practical test. The closing date for entries is February 1st. Application forms and regulations may be obtained from the R.T.E.B., 9, Bedford Square, London, W.C.1.

What is Electronics?

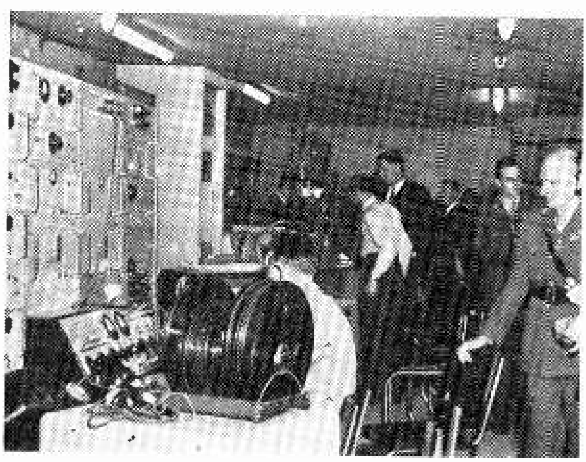
AN OFFICIAL RULING on the proper meaning of the debatable word *electronics* is on the way. The following definitions put forward by the International Electro-technical Commission have been submitted for approval by the various national committees.

Electronics (noun).—That branch of science and technology which deals with the study of the phenomena of conduction of electricity in a vacuum, in a gas, and in semi-conductors, and with the utilization of devices based on these phenomena.

Electronic (adjective).—Qualifies that which is concerned with electronics or any device which functions according to its principles.

C.C.I.R. London Meeting

THE SEVENTH plenary assembly of the C.C.I.R., to which we referred in our last issue, was opened by the Postmaster-General, Earl De La Warr, at Church House, Westminster, on September 3rd.



FIELD MARSHAL VISCOUNT MONTGOMERY, who opened the Earls Court Radio Show, inspecting the sound reproducing equipment in the R.I.C. Control Room. This year's show attracted 295,240 visitors—over 5,000 more than last year.

Attended by over 300 representatives of some 50 countries, the work of the assembly is largely being conducted by comparatively small working parties, each covering a specific subject. The recommendations of these committees are brought before the main assembly for consideration and, if approved, incorporated in the findings of the assembly.

We hope to include in our next issue a report on the assembly which is scheduled to close on October 7th.

Broadcast Station Guide

WITH the coming into force on July 1st of the Stockholm Plan for v.h.f. broadcasting in Europe most of the West German f.m. transmitters have changed their frequencies. These new frequencies and those of all the European v.h.f. stations, totalling about 150, are included in the seventh edition of our book, "Guide to Broadcasting Stations."

As it is two years since the publication of the sixth edition, the preparation of the new edition provided an opportunity of completely revising the information in each of the sections. Details of 1,800 short-wave broadcasting stations of the world and nearly 600 medium- and long-wave European stations are listed both geographically and numerically in order of frequency.

Operating details of some 40 European television stations and the frequencies used by the world's standard frequency transmitters are also given in the 104-page book, which is obtainable, price 2s, from booksellers or by post from our publishers, price 2s 2d.

Educational Opportunities

IN ADDITION to the courses in radio and allied subjects to which we referred in our last issue we have been notified of both full-time and part-time courses covering the Brit. I.R.E. exam., the full technological certificates of the C. & G., the R.T.E.B. television and servicing exams., and the P.M.G.'s certificate exam., at the Norwood Technical College, London, S.E.27.

A "Student's Guide" to courses of study in engineering available in the Manchester area has been produced by the Manchester and District Advisory Council for Further Education. The Council, whose address is Education Offices, Deansgate, Manchester, 3, has also prepared a booklet listing the post-advanced lectures in electrical and mechanical engineering available in the area.

Courses for the radio amateurs' examination are being provided at the Grafton L.C.C. School, Eburne Road, Holloway, London, N.7, on Mondays. Applications should be made to A. W. H. Wennell (G2CJN), 145, Uxendon Hill, Wembley Park, Middx., secretary of the Grafton Radio Society, who are sponsoring the course. An amateurs' course is also being conducted at the Chichester Evening Institute, Orchard Street, Chichester, on Wednesdays.

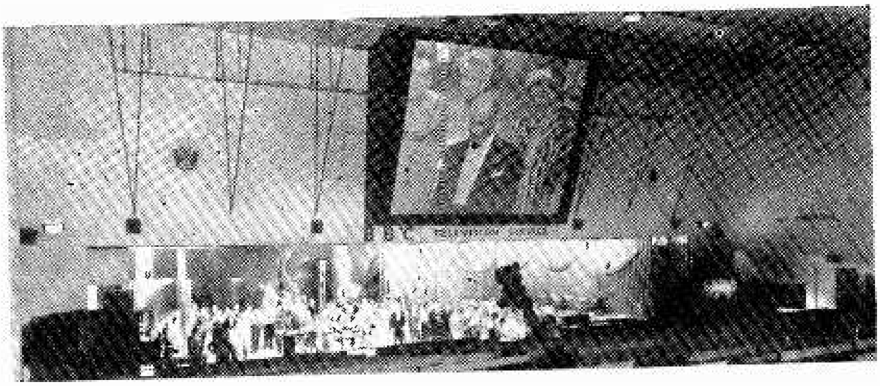
PERSONALITIES

Dr. B. V. Bowden, M.A., A.M.I.E.E., the new principal of the Manchester College of Technology, was head of the Computer Group of Ferranti which he joined in 1950. After spending three years in the Cavendish Laboratory, Cambridge, with Lord Rutherford and four years in the scholastic world he joined T. R. E. Malvern, from which he took a team to the Naval Research Laboratory, Washington, to work on an aircraft identification system. From 1945 he was for a short while at the Massachusetts Institute of Technology, after which he joined Sir Robert Watson-Watt's consulting organization before going to Ferranti's.

L. H. Bainbridge-Bell, whose absorbing personal interest is the clear presentation of technical information (particularly in diagrams), has joined the British Standards Institution as a committee secretary in the Electrical Section. He will assist in the preparation of glossaries and the standardization of terms and definitions in the electrical field. He recently retired from the Admiralty Signal and Radar Establishment which he joined in 1939.

Edward B. Bull, founder and managing director of Welwyn Electrical Laboratories, Ltd., of Bedlington, Northumberland, manufacturers of resistors and capacitors, died in August.

Harry Diggle, managing director of Hivac, the valve manufacturing subsidiary of the Automatic Telephone and Electric Company, died on August 17th. In 1932, in collaboration with Stephen de Laszlo, he founded the High Vacuum Valve Company, which was responsible for considerable work in the field of valve miniaturization. This company was succeeded in 1939 by Hivac, Ltd.



LARGE SCREEN TV.—A 21-ft screen erected above the proscenium at the Earls Court Studio and smaller screens at the sides enabled the audience to see the transmitted picture as well as the full stage production. The equipment was installed by Cinema-Television.

F. T. Cotton, B.Sc., who joined Hivac in January this year as engineer-in-chief, has been elected a director of the company. He was for 15 years with the Cossor organization and was for some time chief valve engineer of Electronic Tubes of High Wycombe. Since leaving Electronic Tubes in 1947 he has been with Ekco-Ensign and the English Electric Valve Company.

W. E. Miller, M.A. (Cantab.), who is to be the president of the British Institution of Radio Engineers for a second year, has been editor of the *Wireless and Electrical Trader* since 1940 and was previously technical editor for 14 years. His journalistic career started in 1925 when he joined the staff of *Experimental Wireless*, now *Wireless Engineer*.

The Trix Electrical Co., Ltd., have appointed two new directors: **C. E. Redrupp**, who has been in charge of technical development and design during his 20 or more years with the company, and **M. L. Berry**, who will continue on the sales side of the business.

OUR AUTHORS

E. W. Rogers, contributor of the article on acoustic response curves in this issue, is chief of the Communications Department of Redifon, Ltd., having previously been chief designer in the department from 1945 to 1952. He served his apprenticeship in the Audio and Acoustic Laboratories of E.M.I. at Hayes from 1929 to 1936, following which he was for two years with Cossor's as a development engineer. He joined Rediffusion, Ltd., an associate company of Redifon, in 1938.

H. V. Harley, contributor of the article "Valve Matching Using Resistors," on page 488, is a post-graduate student in the University of Wales, where he is doing research work for the Ph.D. degree. During the war he was a senior N.C.O. in the Royal Corps of Signals and in R.E.M.E.

J. I. Missen, who on page 467 discusses the application of transistors in push-pull amplifiers has, since 1949, been engaged in transistor development and circuit applications at the Research Laboratories of the General Electric Company, Wembley. He spent 4½ years during the war in R.E.M.E., maintaining Army radar and telecommunication equipment, after which he was for two years at the Royal College of Science where he gained a degree in Physics.

OBITUARY

R. C. Walker, B.Sc.(Lond.), A.M.I.E.E., A.M.I.Mech.E., who was in charge of the technical and commercial development of photocells, Geiger Müller counter tubes and specialized electronic devices in the General Electric Company's Valve and Electronics Department, died on August 7th, aged 57. Mr. Walker's first association with the company was at the Osram-G.E.C. Lamp Works, Hammersmith, where he was engaged part-time while taking his degree course at Reading University. He joined the staff of the G.E.C. Osram Valve and Electronics Department in February, 1928. He was the author of a number of works on electronics and its application to industry.

IN BRIEF

Thirteen Million.—There are now over thirteen million holders of broadcast receiving licences in the United Kingdom. At the end of July there were 10,531,402 "sound" licences (including 195,075 for car radio) and 2,479,454 television licences, making a total of 13,010,856.

A series of lectures on "**Solid State Physics**" is to be given in London on October 20th and 21st by research engineers from the R.C.A. Laboratories, Princeton, U.S.A. There will be morning and afternoon sessions, with talks and discussions on recent developments in the fields of transistors, electronically active solids, photo-conductivity and television camera tubes. Particulars as to the place and time of the meetings, which were not fixed when we went to press, will be obtainable from the R.C.A. European Representative, C. G. Mayer, 55, Pall Mall, London, S.W.1.

Colour Television has been chosen by the Television Society as the subject of this session's Fleming Memorial lecture. G. G. Gouriet, B.Sc., B.B.C. (Engineering Research Department), has been invited to give the lecture at the Royal Institute, Albemarle Street, London, W.1, at 7.0 on February 12th and 25th. Admission will be by ticket obtainable from the Television Society, 164, Shaftesbury Avenue, London, W.1.

Sound Recording Congress.—An international congress on sound recording processes is being organized by the Société des Radioélectriciens for next spring. The congress, which it is proposed to divide into four sections covering mechanical, photographic and magnetic recording and the problems of standardization, will be held in Paris from April 5th to 10th. Particulars are available from J. Matras, Secretary, Société des Radioélectriciens, 10 Avenue Pierre Larousse, Malakoff (Seine).

"**Electronics—Key to Progress**" is the theme of the ninth National Electronics Conference and Exhibition which is being held in Chicago, Illinois, from September 28th-30th. The proceedings of the conference will be divided into various sessions, including circuitry, ultrasonics, electron tubes, nucleonics, transistors, instrumentation and microwaves. The 100 papers will be published in the *Proceedings of the National Electronics Conference* (Vol. 9), which will be available early next year, price $5.00, from the secretary of the N.E.C., 852, East 83rd Street, Chicago, Illinois.

"**Design for Production**" is the title given by the British Institution of Radio Engineers to a Convention being planned for next July (9th-13th) at Christ Church, Oxford.

An invitation to senior students of technical colleges and like institutions to visit their works at Watford, Herts, is extended by Wild-Barfield Electric Furnaces. The tours are conducted during afternoons (Monday to Friday) and include an inspection of the Research and Development Departments as well as the production plant.

BUSINESS NOTES

Trix.—The note in our last issue regarding the formation of Electric Audio Reproducers, Ltd., might be misconstrued to imply that the new company would market all the record-playing equipment previously handled by Phono Disc, Ltd. The Trix Electrical Co., Ltd., of 1-5, Maple Place, London, W.1, ask us to point out that they will continue to develop and manufacture Trixette gramophones for which Phono Disc, Ltd., were agents until August.

Kelvin Hughes equipment supplied for the 8,000-ton passenger liner *Maori*, scheduled to undergo her trials on September 30th, includes the MS26B echo sounder, which uses Teledeltos recording paper. The liner will be operated by the Union Steam Ship Company of New Zealand.

Marconi Echometer.—Designed primarily for coastal and estuary craft, which normally do not require soundings deeper than 100 fathoms, the new Marconi Marine visual-indicating echometer has a range of 0-130 fathoms. The Visette, as it is called, operates from a 24-volt d.c. supply, has a total power consumption of 20 watts and is completely self-contained in a case measuring 18 × 16 × 14 inches.

E.M.I. Sales & Service, Ltd., have formed a **Recording Equipment Division** which is responsible for the domestic and professional recording equipment designed and produced by the company. Romer Hatton has been appointed sales manager of the Division with R. J. Wood as assistant sales manager and W. H. Y. Grainger as sales engineer.

B.B.C. has ordered four complete mobile television O.B. units from **Marconi's.** Each unit will be equipped with five cameras (two in reserve) with controls and mixers for both sound and vision.

E.M.I. tape recorders and associated equipment recently supplied to the B.B.C. include over fifty portable battery-operated recorders and eighty-five for studio use.

NEW ADDRESSES

Rees Mace.—We were misinformed regarding the new address of the Depot of Rees Mace Marine, Ltd., in Swansea, given in our last issue. It should be 6, Coed Celyn Road, Derwen Fawr, Swansea, Glam. (Tel.: Swansea 87637).

Truvox, Ltd., announce that during extensions to their Wembley works, the general office and home sales and export departments are temporarily at 15, Lyon Road, Harrow, Middlesex. (Tel.: Harrow 9282.)

MEETINGS

Institution of Electrical Engineers

Inaugural address of the president, H. Bishop, C.B.E., B.Sc. (Eng.), on October 8th.

Discussion on "Television" opened by the president on October 19th.

Radio Section.—Address by J. A. Smale, C.B.E., B.Sc. (chairman), on October 14th.

Discussion on "Long Playing Disc Records Compared with Magnetic Tape for Sound Reproduction in the Home," opener H. F. Smith, on October 26th.

All the above meetings will be held at 5.30 at Savoy Place, London, W.C.2.

Cambridge Radio Group.—Address by D. Weighton, M.A. (chairman), at 6.0 on October 13th at the Cambridgeshire Technical College.

North-Eastern Centre.—"Television Broadcasting Stations," by P. A. T. Bevan, B.Sc., at 6.15 on October 26th at the Neville Hall, Westgate Road, Newcastle-upon-Tyne.

North-Eastern Radio Group.—Address by F. H. Birch, B.Sc. (chairman), at 6.15 on October 5th at King's College, Newcastle-upon-Tyne.

North-Western Radio Group.—"Colour Television," by A. J. Biggs, Ph.D., B.Sc., at 6.30 on October 21st at the Engineers' Club, Albert Square, Manchester.

South Midland Radio Group.—"Special Effects for Television Studio Productions," by A. M. Spooner, B.Sc. (Eng.), and T. Worswick, M.Sc., at 6.0 on October 26th at the James Watt Memorial Institute, Great Charles Street, Birmingham.

North Staffordshire Sub-Centre.—"The Control of a Thermal Neutron Reactor," by R. V. Moore, G.C., B.Sc. (Eng.), at 7.0 on October 26th at the Technical College, Stafford.

Southern Centre.—"Special Effects for Television Studio Productions," by A. M. Spooner, B.Sc. (Eng.), and T. Worswick, M.Sc., at 7.30 on October 28th at the R.A.E. Technical College, Farnborough.

British Institution of Radio Engineers

London Section.—"The Impact of Information Theory on Television," by D. A. Bell, M.A., B.Sc., Ph.D. (University of Birmingham), at 6.30 on September 30th.

Annual General Meeting, followed by "Printed Circuits: Some Principles and Applications of the Foil Technique," by P. Eisler, Dr. Ing. (Technograph Electronic Products), at 6.0 on October 21st.

Both the above meetings will be held at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1.

North-Western Section.—"The Detection and Cure of Parasitic Oscillations in Radio and Electronic Equipment," by H. Whalley (Metropolitan Vickers), at 7.15 on October 1st at the College of Technology, Manchester.

North-Eastern Section.—"The Impact of Information Theory on Television," by D. A. Bell, M.A., B.Sc., Ph.D. (University of Birmingham), at 6.0 on October 14th at the Institution of Mining and Mechanical Engineers, Newcastle-upon-Tyne.

Scottish Section.—"The Microwave Test Bench and Its Components—a practical introduction to waveguide work," by J. Bilbrough (Microwave Instruments), at 7.0 on October 8th at the Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2.

Television Society

London.—"Recording Television Programmes," by C. B. B. Wood (B.B.C. Research Dept.), at 7.0 on October 9th.

"Flywheel Synchronizing and Scanning Circuits," by H. Fairhurst (Murphy Radio), at 7.0 on October 22nd.

Both the above meetings will be held at the Cinematograph Exhibitors' Association, 164, Shaftesbury Avenue, London, W.C.2.

Bedford Centre.—"Large-Screen Television," by T. M. C. Lance (Cintel), at 8.0 on October 7th.

"The Importance of the D.C. Component," by D. C. Birkinshaw (B.B.C.), at 8.0 on October 14th.

Both the Bedford Centre meetings will be held at the Clapham Road Schools, Bedford.

Leicester Centre.—Lecture-demonstration on the application of the cathode-ray oscillograph to television servicing by H. J. Beech at 7.0 on October 19th at the Leicester College of Technology.

British Sound Recording Association

London.—"Fundamentals of Disc Reproduction," by S. Kelly, at 7.0 on October 23rd at the Royal Society of Arts, John Adam Street, London, W.C.2.

Institute of Practical Radio Engineers

Midlands Section.—"Electrical Indicating Instruments," by W. Pierce (Crompton Parkinson), at 7.30 on October 5th at the Crown Hotel, Broad Street, Birmingham.

Institution of Production Engineers

Glasgow Section.—"High-Frequency Heating and Induction Hardening," by R. H. Barfield, D.Sc., at 7.30 on October 15th at the Instituion of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2.

Institution of Works Managers

Glasgow Branch.—"Electronics in Materials Handling," by L. Landon Goodman, B.Sc. (Eng.), (British Electrical Development Association), at 7.15 on October 26th at the Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2.

CLUB NEWS

Cambridge.—The first lecture of the new session of the Cambridge University Wireless Society will be given on October 12th by J. M. Carter (Wright & Weaire), who will talk on tape recording. Sec.: R. C. Marshall, St. John's College, Cambridge.

Cleckheaton.—"Radar 1939-1945" is the title of the talk to be given by W. Ripley (G4AD) to members of the Spen Valley and District Radio and Television Society on October 7th. At the following meeting (October 21st) Capt. R. E. Perry, of the U.S.A.A.F., will speak on "Ham Radio in U.S.A." Meetings are held at 7.30 at the Temperance Hall, Cleckheaton. Sec.: N. Pride, 100, Raikes Lane, Birstall, nr. Leeds.

Edinburgh.—In addition to the regular meetings on alternate Thursdays at 25, Charlotte Square, Edinburgh, the Lothians Radio Society has arranged visits to the Kirk o' Shotts television transmitter on October 11th and 18th. Sec.: L. Stuart, 38, Caledonian Crescent, Edinburgh.

TRANSISTORS

By THOMAS RODDAM

9.—*Complementary Symmetry and Its Application in Circuits for Television Reception*

COMMUNICATION engineers, as a class, are concerned with two quite different kinds of problems. On one side, the solid, plodding, public-service engineers, who have to do with telephones, transmitters and the like, are forced to consider the problems of life, stability and long-term reliability: just what this means you can see by looking in a recent *Bell System Technical Journal* for a series of papers on how to twist a wire round a tag. The broadcast receiver engineer, on the other hand, must always be penny wise: it is not for him to consider what the capitalized cost of current and repairs will be over a 20-year period.

So far in this series we have tended to look towards the Marthas of the transistor world, but this month, for a change, we shall see what has been going on in another place, the receiver laboratory.

A television receiver probably contains more circuit types per cubic inch than any other electronic equipment: there are linear circuits and non-linear circuits, low frequency circuits and high, oscillators and amplifiers. The production of a completely transistorized television receiver is thus a rather striking stage in the development of the transistor: the production of one hundred television receivers would be a revolution and a revelation. The first television receiver using no ordinary valves—except, of course, the cathode-ray tube—has recently been described by Mr. G. C. Szicklai,[1] whose lecture in London was reported in the August issue of this journal. This receiver, which has a 5-inch picture tube, uses 37 transistors and takes only 13 watts from the battery. It is portable, but unlike most American receivers it cannot be tuned over a wide band, and is arranged to receive only one station, channel 4 of the American system (67.25 Mc/s).

The circuit techniques used in this receiver are of considerable interest, and it is proposed to give a short general survey of them in this article. A word of warning is necessary. Many of the transistors used in this receiver are either specially developed units or transistors picked out to fit a particular specification. Even if your rich uncle in America will send you half a gross of transistors you will not find it possible to build yourself a television set.

Fig. 1 shows the block schematic of the television receiver. Although this diagram does not make it too clear, the receiver consists of a superheterodyne circuit in which the intermediate-frequency amplifier is followed by two second detectors, one for the intelligence, sound and vision, and one for the control functions, the synchronizing signals. Thus the upper second detector feeds into the video amplifier and into the inter-carrier frequency stages, ratio detector and audio amplifier. As you will remember, the American television system uses f.m. for the sound, and the sound signal can be extracted at the beat frequency between the sound and vision carriers. The lower second detector feeds into a sync separator and provides the control for the two scanning chains. This splitting was introduced because the sync amplifier loaded the second detector too much to give satisfactory performance in the intelligence channel.

The receiver uses a balanced diode mixer circuit which is tapped down on the frame-aerial/tuning-circuit system. The frame aerial is tuned by a parallel LC circuit to 67.25 Mc/s, and a 60 Mc/s local oscillator signal is injected at the mid-point of the frame. The oscillator itself, using a point transistor, is in appearance simply one of the circuits we discussed earlier, using the positive feedback produced by a high impedance in the base. As we mentioned in the previous article, however, the phase shifts in the transistor itself play an important part at these high frequencies, and the capacitance from emitter to earth, which does not appear in the circuit diagram, Fig. 2 forms an essential part of the oscillatory circuit. This oscillator produces a diode current of 1mA, and the mixer circuit is stated to have a loss of 6 db.

There are six stages of i.f. amplification, which are stagger-tuned and give a flat response from 7.5 Mc/s to 9.5 Mc/s. Two of these stages are shown in the circuit of Fig. 2 and it will be seen that an earthed

[1] "A Study of Transistor Circuits for Television," by G. C. Sziklai, R. D. Lohman and G. B. Herzog. *Proc. I.R.E.*, June, 1953, p. 708.

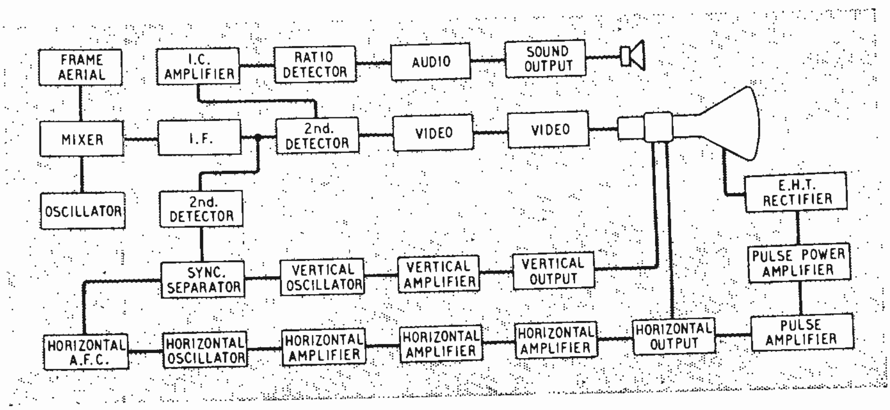


Fig. 1. Block schematic diagram of experimental transistor television receiver.

base circuit is used. The TA-166 is a point transistor, and this type of transistor is also used for the second detector. The only real difference between the i.f. amplifier stages and the detector is that the detector is operated at zero emitter bias current, thus giving the wanted non-linearity.

The video amplifier is, I suspect, not the arrangement which would be used for a new development. The circuit is shown in Fig. 3. The point transistor, TA-166, was required in order to get a sufficiently good response at high frequencies. The inductance L_3 in the collector circuit is the usual peaking coil for compensation of the output capacitance. Additional compensation is provided in this stage by using positive feedback in the base: the combination of B_2 and L_2 provides an increasing amount of feedback as the frequency rises, while the stage is kept stable by the high impedance in the emitter circuit presented by the collector of the junction transistor. The main job of this junction transistor is to provide a fairly high input impedance, and the gain of this stage is reduced, with some improvement in response, as a result of the negative feedback introduced by R_1. Not shown in this circuit is a resonant circuit tuned to 1 Mc/s which shunts R_1 and thus reduces the negative feedback to provide response correction. The resulting response is flat up to about 2 Mc/s. The bleeder resistors for the base bias which we discussed in Part 6 of this series will be noted in this circuit. It might perhaps be pointed out that the junction transistor here is a *p-n-p* type.

The load resistor is 2,700 ohms, and the TA-166 point transistor gives an output of 8 volts peak-to-peak across this load. The whole of this swing is used for picture, the sync pulses being crushed by overloading. This is another reason for providing the separate synchronizing system. The synchronizing path, which begins with the second detector shown in the third row of Fig. 1, is tapped down on the driving transformer. It starts off with its own detector, which is followed by two junction transistors of type TA153. The first of these is an earthed-base circuit without emitter bias and acts as a sync separator, the second is a conventional earthed-emitter amplifier circuit. The vertical oscillator is controlled by the integrated sync pulses, while a rather complex a.f.c. circuit, which I do not propose to describe here, is provided for the horizontal circuit.

The vertical oscillator itself is shown in Fig. 4. This is a variant on one of the circuits discussed in Part 5 of this series, though it is now the saw-tooth decay, up path 4 of Fig. 6, page 258, June issue, which is of interest, not the pulse. This oscillator is designed to run slightly slow, so that it can be driven by positive pulses applied to the emitter: these are the pulses produced in the vertical integrator. Three stages of amplification are used, the final stage, which produces a peak-to-peak current of 100 mA in a 65-ohm, 45-mH deflection coil, being a "Sziklai special," using complementary symmetry[2].

The key to this new idea of complementary symmetry is the possibility of making two kinds of junction transistors, *n-p-n* and *p-n-p*: once this possibility is realized it becomes logical to show the general set of junction transistor curves in the form of Fig. 5. These curves are the collector current-voltage characteristics, measured in an earthed-emitter circuit with base current as parameters. The + signs correspond to an *n-p-n* transistor and the − signs to a *p-n-p* unit. Normally, of course, these characteristics will not have numbers on the scales, but will be "generalized characteristics," but R.C.A. had a bright idea of producing a complementary pair, transistor and "transistor-

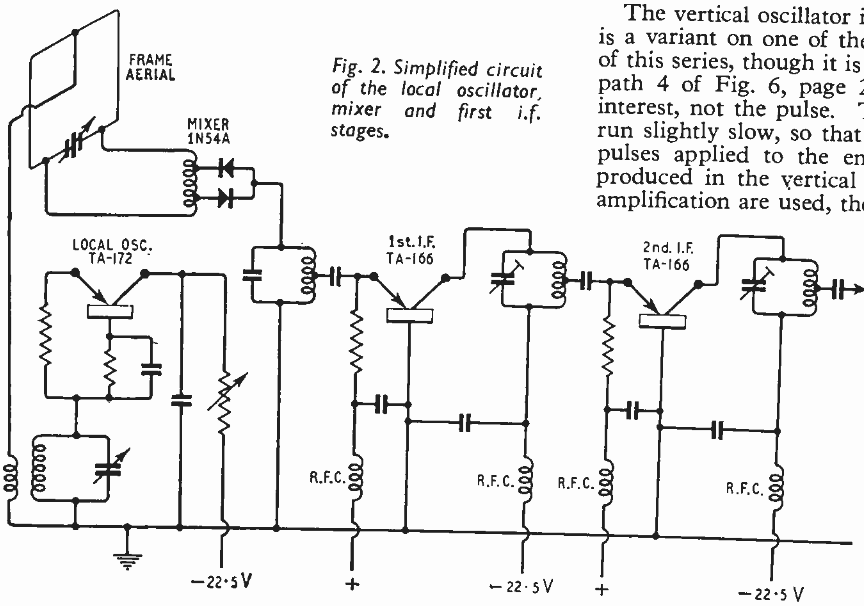
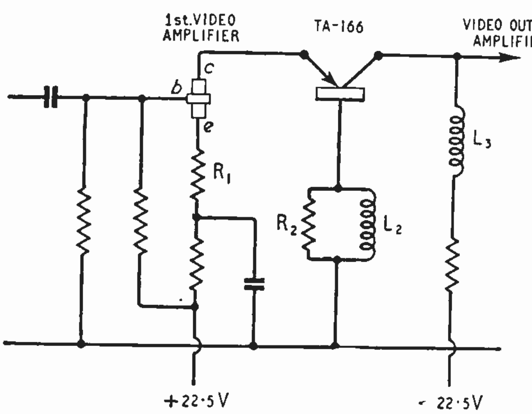


Fig. 2. Simplified circuit of the local oscillator, mixer and first i.f. stages.



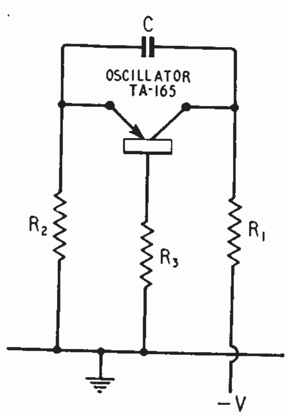


Fig. 3. Essential features of the video amplifier. Right: Fig. 4. Vertical-deflection oscillator

[2] "Symmetrical Properties of Transistors and their Applications," by G. C. Sziklai. *Proc. I.R.E.*, June, 1953, p. 717

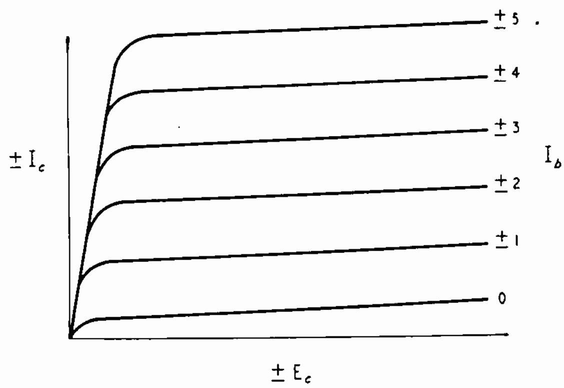


Fig. 5. Complementary characteristics of n-p-n *and* p-n-p *junction transistors.*

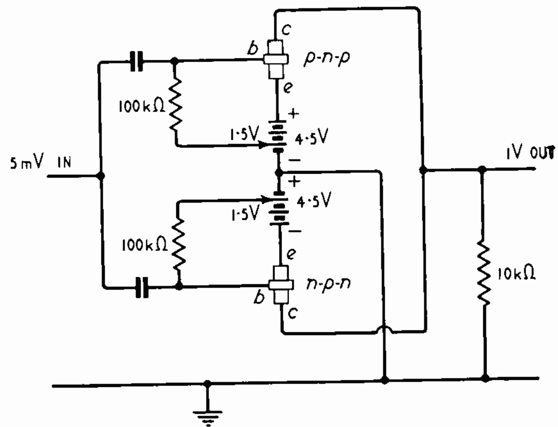


Fig. 6. Transistor push-pull amplifier circuit making use of complementary symmetry.

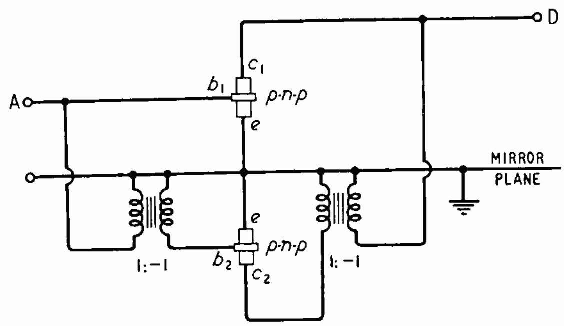


Fig. 7. Use of transformers to get push-pull operation with p-n-p *transistors.*

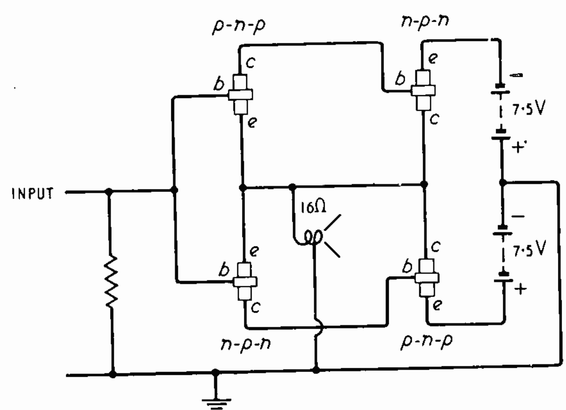


Fig. 8. Two-stage complementary symmetry Class B system with negative feedback.

through-the-looking-glass," so that numbers could be put on which would apply to the mirror pair. If you now consider a working point somewhere in the middle of the diagram and a load line across it you will see that if the base current is increased, in the sense of "made more positive," the collector current will increase by becoming a smaller negative current, as the base current becomes less negative. It is very important to keep an eye on the signs here: a current of −6mA is considered to be less than a current of −5mA.

As a result of this effect, a mirror-pair of transistors fed in parallel, with outputs connected in parallel, will behave like a push-pull amplifier and will, in particular, give the well-known even-harmonic balance. The reader is recommended to examine this closely for himself, by testing what happens as the base current is driven.

A typical circuit is shown in Fig. 6, with some values. This circuit operates in Class A, giving a gain of 46 db. Higher gains are obtained if the load resistance is increased, as you would expect with a pentode-like transistor. In Fig 7 an alternative way of approaching the circuit is sketched. Here ideal 1 : 1 transformers are used to reverse the signs in the lower path. The mode of operation is easily followed: as A is made positive, *b*1 becomes positive and *b*2 negative; *c*1 goes negative, while *c*2 goes positive, but because of the second 1 : −1 transformer the point D is driven negative by both transistors. Now we replace the combination transformer: *p-n-p* transistor: transformer, by an *n-p-n* transistor and simply twist the lower half of the circuit up to the other side of the mirror plane, and we have, apart from the supply and bias circuits, the system of Fig. 6.

One version of this circuit will operate directly into the 500-ohm coil of a loudspeaker (one of the loudspeakers designed for use with the Peterson and Sinclair single-ended push-pull amplifier[3]), and the heavy and bulky output transformer normally needed is thus eliminated. A well-balanced pair of transistors will produce no standing current in the load: the coil is therefore not subjected to any permanent shift away from the centre of the field. This feature is of great value if the circuit is being used to drive the deflection coils of a cathode ray tube.

In the transistorized television receiver a circuit of this general type is used, but the load is connected in the common emitter lead, and the two transistors are operated in the earthed-collector mode. Supply voltages of + and −4½ volts give a current which varies from −50 mA to +50 mA in the 65-ohm, 45-mH coil of the vertical deflection circuit.

An amplifier based on this principle whic' is especially attractive is shown in Fig. 8. This is a Class B system directly coupled to a second Class B system with quite a large amount of negative feedback from

[3] *Proc. I.R.E.*, Jan., 1952, p. 7, and *W.W.*, May, 1952, p. 203.

output collectors to the emitters of the input stage. The feedback makes it possible to work into a 16-ohm load, and a maximum power rating on programme peaks of 0.5 watts is permissible. The input impedance is high, and the power gain is about 28 db. As the efficiency is nearly 50 per cent and the circuit takes almost no current in the absence of a signal, the power drain is only about 100 mW, a very surprising figure for a 500 mW output amplifier.

There are further variants on this theme of complementary symmetry, and some of these exhibit the same remarkable simplicity as Fig. 8, which, it should be noted, is a complete circuit diagram with nothing left out. An amplifier of this type contains no components except the transistors, the holders and the terminals. Design follows the usual combined characteristic process we already know in valve circuitry for fitting together the curved characteristics of Class B stages.

The line time-base system of a television receiver with magnetic deflection raises some special problems, because the amount of energy involved is very considerable. It is not the need to dissipate energy, for which we should need only high-power amplifiers: the problem in a horizontal deflection system is to control the large amount of energy which must be stored in the coils at the ends of the sweep. The charge on a capacitance represents potential energy, while the magnetic flux corresponds to the kinetic energy. We try to save up the energy in a capacitor for use in the next sweep, to economize in power consumption. Transistors can be of great value here.

The horizontal deflection circuit of the transistorized television receiver uses a cross-connected pair of transistors or a special symmetrical transistor unit. The basic arrangement and its equivalent circuit are shown in Fig. 9, in which the cross-connected pair of transistors is replaced by a resistor R and a switch in the equivalent circuit. When the common base lead is held negative by, say 10 volts, the transistors provide a resistance of only about 1 ohm to currents in either direction—up to currents of the order of 500 mA—while if the base lead is made positive the switch is opened and has a leakage resistance which is of the order of 50 kilohms. The analysis of this circuit is carried out by considering three phases, starting from the switch open and system at rest condition.

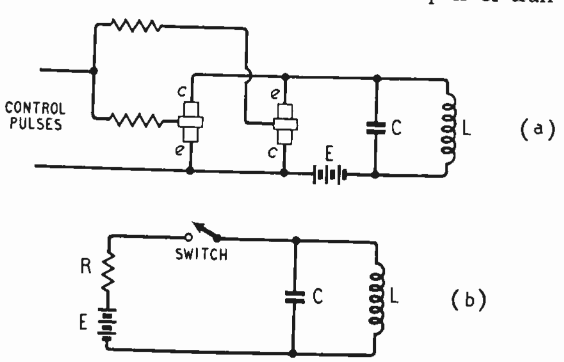


Fig. 9. (a) Circuit of transistor "switch" used in line time-base circuit. (b) Equivalent circuit.

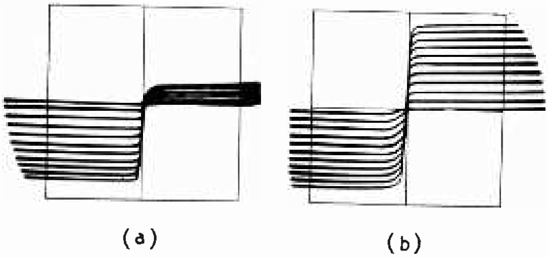


Fig. 10. Collector current curves taken on a curve tracer for (a) asymmetrical and (b) symmetrical junction transistors.

The first phase being when the switch is closed. Provided that we do not allow this phase to last for times comparable with L/R the current in the coil grows linearly with time, and at the end of time T has reached a value ET_1/L.

The second phase being when the switch is opened The coil is already "charged," and an oscillatory current is thus produced in the LC-circuit. After a half-cycle, which takes a time $T_2 = \pi\sqrt{LC}$ the current in the coil has reversed, but the magnitude is again ET_1/L.

The third phase begins when the coil is carrying a current $-ET_1/L$. The switch is closed and the battery starts to drive a current into the coil. Just as in phase 1, the current rises linearly, but it is now arising from $-ET_1/L$, so that after a time $T_3 = T_1$ the current will have reached zero.

These are just the conditions corresponding to the beginning of phase 1: no current in L, and switches closed. The linear run up of the current thus continues quite smoothly.

It is not very economical to use two transistors for this job of producing the horizontal deflection, and a special symmetrical transistor has been produced to replace the cross-connected pair. This symmetrical transistor is a *p-n-p* junction type in which the two *p*'s are the same, so that you cannot tell emitter from collector. Many early transistors were like this, but it remained for Sziklai to see how this feature could be used and to ask the transistor makers, who had worked hard to find how to make emitter and collector different, to go back and rediscover how to make them exactly the same. Their success is indicated quite clearly by the curves shown in Fig. 10.

The general circuit arrangement of a deflection system using a symmetrical transistor is very similar to the circuit using the cross-connected pair, and anyone who is interested in more detail should turn to the two papers quoted. The actual performance obtained is rather interesting. For the 5-inch tube a peak-to-peak current of 1.2 A is obtained, and the supply consumption is only 70 mA from a 13-volt source. The peak flyback voltage is 120. The efficiency of the circuit is rather more than twice that of the best valve circuits, even if the valve heater is not included in the balance sheet. The losses are equally distributed between the transistor and the deflection coils.

There are quite a number of other applications for a symmetrical transistor: among those which may be mentioned are modulators, phase detectors, f.m. detectors and clamp circuits. These circuits can be studied experimentally by using a cross-connected pair, though some of the transistors have such normally undesirable properties that they might well prove of direct use as symmetrical transistors!

Acknowledgement.—Figs. 1, 2, 3, 4, and 9 are based on Figs. 1, 2, 5, 8 and 12 of reference 1, and Figs. 5, 6, 8 and 10 on Figs 1, 2, 8 and 14 of reference 2 (*Proc. I.R.E.*).

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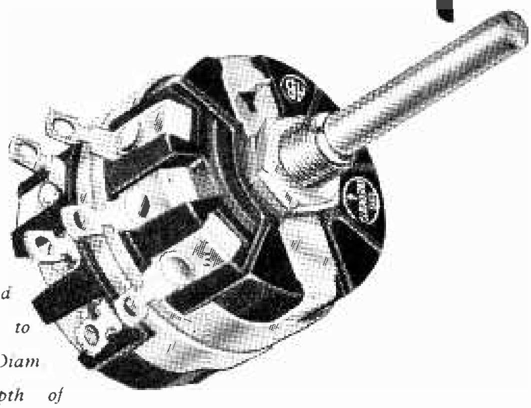

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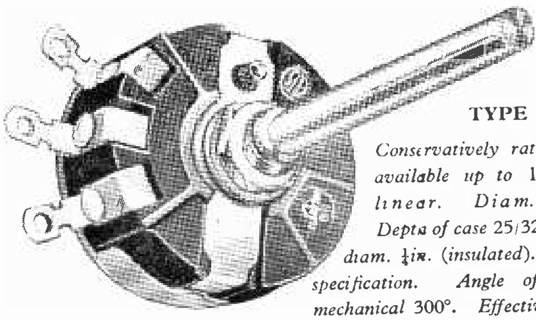

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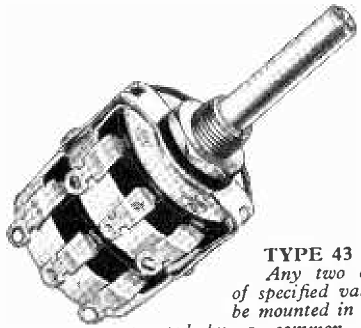

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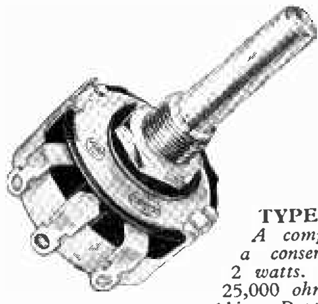

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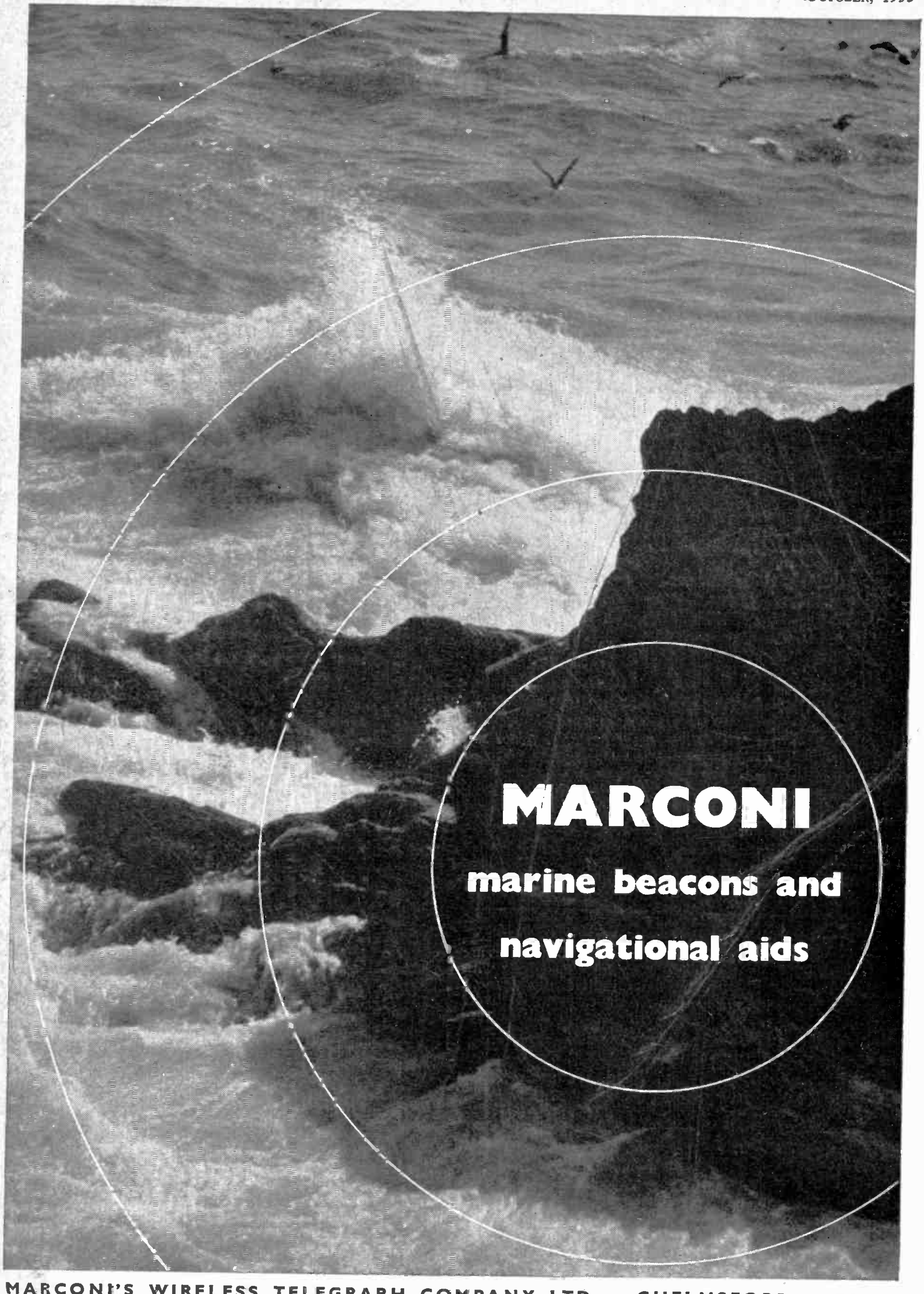
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More Valves for Microwaves

2.—*Velocity Modulation of the Electron Beam*

By "CATHODE RAY"

NEW readers (and old ones who have forgotten) start here. "Microwaves," for the present purpose, are chiefly those in what is known officially as the s.h.f. ("super-high" frequency) band, from 3,000 to 30,000 Mc/s, wavelengths 10 to 1 cm. Among other things they are used for radar and for linking up the B.B.C. television system. A notable example is the Manchester-Edinburgh chain of links on about 4,000 Mc/s. Valves working according to the usual principles are little or no good for such high frequencies; for one thing, the time that electrons take to cross from one electrode to another is an appreciable part of an s.h.f. cycle, and this leads to various complications; for another, it is difficult to make the distance between the tuning circuits and the working surfaces of the electrodes less than an appreciable fraction of a wave-length. By dint of making the electrodes part of the tuning system and reducing the electrode clearances to paper thickness, exceptional triodes ("disk-seal" type) have been produced capable of oscillating and even amplifying at around 3,000 Mc/s, but their power and amplification are small. A complete breakaway from ordinary valves is the magnetron, capable of almost incredible performance under pulsed radar conditions—peak output at 3,000 Mc/s of several thousand kilowatts, for example. It can also be designed to work at much higher frequencies, but since the whole of the tuned circuit is part of the valve a different size of valve is needed for each frequency band. The magnetron is a diode, with heated cathode and positive anode, but unlike ordinary diodes its electrons flying from cathode to anode are influenced not only by the h.t. voltage but also at right angles by the force of a powerful magnet, and the energy imparted to them by the h.t. is not delivered to the tuned circuit after they have arrived at the anode, in the form of grid-controlled anode current, but actually while they are still flying around in the space between the electrodes. Incidentally, it is the interchange of energy between an electrode and electrons moving near it that puts the grid of an ordinary valve more or less out of action at these frequencies. This transit-time effect rules out ordinary valves because it comes in the wrong phase, but magnetrons profit by it because with the help of the magnet it is made to occur in the right phase.

Now that we have, I hope, become used to the idea of tuned circuits that are just little hollows or cavities, and the idea of electrons taking or giving energy to electrodes without actually touching them, it will be easier to tackle the two other main types of microwave valves—klystrons and travelling-wave tubes. After that we can sum up by comparing the merits and limitations of all four types.

I wonder, though, whether there is still some lack of conviction about the influence of flying electrons. Cavity tuning is just a further development of the tendency towards combined and distributed inductance and capacitance exemplified on so many house-tops in the simple dipole, to say nothing of the acoustic analogy presented by sound resonance in rooms—or in a sea-shell held close to the ear. But analogies are not quite so helpful when it comes to visualizing the giving and taking of energy by flying electrons. A falling brick does not impart appreciable energy to anything until it actually hits it. One can study quite considerable books on valves without coming across any hint that the electrons do things to the valve circuits while they are still travelling through space. The reason is that except at microwave frequencies such effects are usually negligible. Of course, it follows directly from basic principles that work is done on a charge that is moving towards an opposite charge under the force of attraction, and vice versa, but this sounds rather highly theoretical and somehow it is difficult to picture action taking place in a circuit due to electrons moving *near* it. Yet that is what is happening in a capacitor with dielectric material between the plates. It can store more energy when the material is there than when it is not, because the material contains large numbers of electrons on an elastic string, as it were, and when a voltage is applied between the plates they move towards the positive plate, straining at the leash. When the capacitor is discharged they give up this extra energy while they are being pulled back *against* the attraction of the positive plate.

Or consider what happens at the grid of an ordinary valve (Fig. 1) if a large negative voltage is suddenly applied. All the electrons in the space move away from the grid as fast as they can. Those that had passed through the grid and were on their way to the anode are speeded by a kick in the pants from the repellent negative grid voltage, and those that were on their way towards the grid receive this blow in the face and hurry back on their tracks. The moving of all these negative charges away from the neighbourhood of the grid would upset the potential of the grid unless some negative charges were moved on to it, and these charges flowing in from the negative battery constitute a current, just as if a conductive

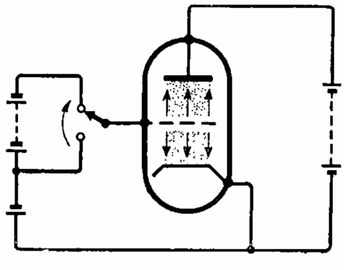

Fig. 1. When the grid of a valve is suddenly made very negative, all electrons in the space are driven away from the grid. While they are doing so, their movements cause grid current to flow, and if this condition is maintained by making the grid potential alternate at thousands of megacycles per second the resulting power loss is heavy.

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path had been placed between grid and cathode. An s.h.f. signal applied to the grid alternates so rapidly that the wretched electrons are continuously being pushed and pulled to and fro before they have time to get anywhere, and the compensating current that has to flow in the grid circuit is so large that it inflicts intolerable damping on that circuit. Which is why the grid-controlled kinds of valve won't work. This resistive current must not be confused with the capacitive current that also flows and which could perhaps be neutralized by inductance without serious loss. Whereas no current flows into or out of a capacitance so long as the voltage across it is constant, a constant voltage continues to drive electrons away from the interelectrode spaces as long as any remain there.

Now suppose that electrons are kept out of the space by absence of anode voltage, combined with slightly negative grid. Switch on the h.t. voltage, and a mob of electrons will surge forward from the cathode. During the minute fraction of a microsecond during which they are crossing the space to the grid, the grid potential would be upset by the approach of this negative charge if a small positive charge were not brought on to the grid. In practice a positive charge is brought by removing electrons, and the flow of electrons *against* the e.m.f. of the grid bias source means that energy is flowing into that source. This energy, even if very small, must come from somewhere, and, of course, in this case it is coming from the h.t. which is responsible for the forcible movement of electrons towards the grid.

Klystrons

The various kinds of klystron are designed to transfer energy to and from circuits by electrons streaming past them rather than into them.

Imagine then that a stream or beam of electrons has been produced by a "gun," just as in a cathode-ray tube, and that it is shooting upwards at a constant speed. In Fig. 2 the numbers 1-10 on the left show the positions of selected electrons in the beam at "zero" time, which is indicated by 0 on the horizontal scale, marked in very small units of time. The diagonal lines enable the positions of the electrons to be found at other times; for instance, after 4 time units have elapsed electron 1 is at position 1′, having moved four spaces upward; electron 2 is at 2′, and so on. If the electrons were moving faster, this would be shown by diagonals sloping more steeply, and vice versa. Because they are all moving at the same speed all the lines are at the same slope.

Next, suppose that at the position marked 1 there are two holes or grids through which the beam must pass in quick succession, and that these electrodes are connected to opposite ends of a tuned circuit that is kept in oscillation (Fig. 3). Then during the half-cycles when the upper or second grid is positive there is an electric field between the grids tending to accelerate the electrons, and during the negative half-cycles the electrons are retarded. Let us trace this effect on the position-time diagram for several half-cycles (Fig. 4). Until the electrons reach position 1, where the grids are, everything is as in Fig. 2. The sine-wave drawn at the foot along the time scale shows that at zero time the inter-grid voltage is maximum positive, and the gain in speed of electron No. 1, which is then passing under its influence, is shown as a 25 per cent increase in the slope of its diagonal. The time units are now seen to be eighths of a cycle. So

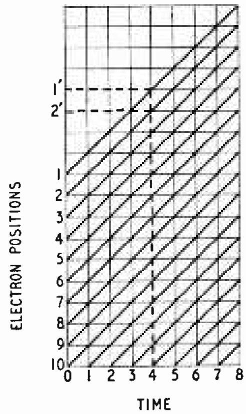
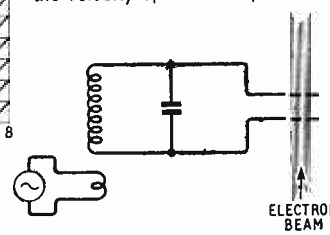


Fig. 2. Diagram showing progress of selected electrons upward at constant velocity, represented by constant slope of the diagonal lines.

Below: Fig. 3. In the klystron the alternating voltage across a tuned circuit kept in oscillation (here represented by conventional symbols, though actually a cavity resonator is used) is used to vary the velocity of a beam of electrons.



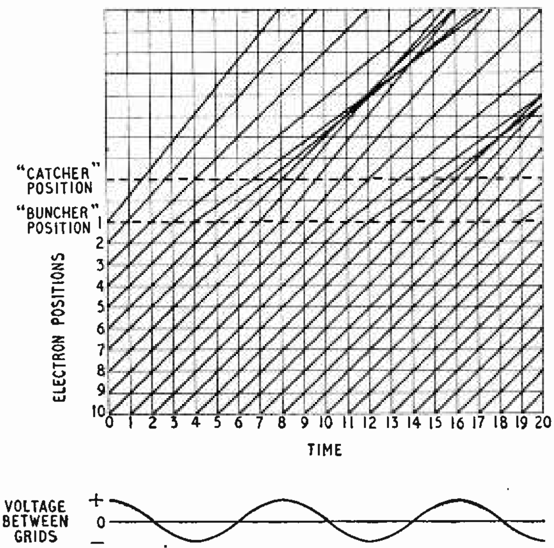


Fig. 4. When the alternating voltage across the tuned circuit (represented by the waveform at the foot of this diagram) is positive, an electron passing under its influence (at the "buncher" position) is accelerated, as indicated by a steepening of the diagonal line from there on. Negative voltages cause deceleration. The result is bunching, as seen at the "catcher" position.

one time unit later the voltage is $1/\sqrt{2}$ or 0.707 times peak, and from position 1 onwards the second electron is shown travelling $0.707 \times 25 = 17.7$ per cent faster than before. When the third electron passes between the grids their difference of potential is zero, so it continues at its original pace. No. 4 is *retarded* 17.7 per cent; No. 5, 25 per cent; and so on. If we now transfer our attention to a point two spaces above the grid position and watch the electrons fly past we notice—as the diagram clearly shows—that some of them come at longer intervals and others closer together in bunches, like a badly run bus service. Comparing them with the foot of the diagram we see that the periods of sparser electrons synchronize with the negative half-cycles of oscillation, and the bunches with the positive half-cycles. Remember that the electrons shown in the diagram are only selected "tracer bullets" representing the vastly greater numbers being shot upward. Compared with the average beam current arriving at the grids, the current passing the higher position is alternately negative and positive, in synchronism with the oscillatory grid potentials. So if we were to put here a second pair of grids connected to a circuit tuned to the same frequency, periodically varying beam current would induce in this second circuit an oscillatory current. Since most of the energy of the electrons is due to the anode voltage of the gun, and the energy required from the first tuned circuit to bunch them is relatively small, it turns out that under suitable conditions the oscillatory power developed in the second tuned circuit is greater than that in the first. So the possibility of amplification is opened up. And by back-coupling the second circuit to the first, one can obtain continuous oscillation.

For obvious reasons the first pair of grids is called the buncher. The second is called the catcher, though this name is rather misleading, for it is the energy of the electrons that is caught, rather than the electrons themselves. There is in fact a final electrode called the collector, because that is what it does. The whole point of this scheme being to operate at microwave frequencies, the conventional tuned circuit shown in Fig. 3 is unsuitable. Resonant cavities are used, through which the beam passes. One form, shown in section in Fig. 5, is shaped like an American doughnut. Another type is actually a short section of coaxial "line." The gun consists of a cathode, surrounded except at the outlet by a control electrode at about the same potential, and an anode to bring the electrons out at speed; but except in high-power transmitting klystrons the anode voltage is lower than in television c.r. tubes—sometimes less than 1,000 V. Fig. 4 shows that the catcher might be even more effective if placed farther away from the buncher, but of course the phase difference between the two resonators would be different; and obviously the best position would depend on the initial speed of the electrons, controlled by the anode voltage.

This bunching process is called velocity modulation, to distinguish it from the process by which the control grid in an ordinary valve produces bunching at more or less constant electron velocity.

Klystrons have been designed on the principle just described with some success as amplifiers of microwaves, but unfortunately they are rather noisy so cannot be used effectively to amplify very weak signals. The same principle has been adopted in power oscillators developing up to several hundred watts continuously at around 4,000 Mc/s, which considering that something of the order of 1 watt is enough for the B.B.C. television network links seems to be adequate, to say the least.

For low-power oscillators, used in signal generators, and especially as superhet oscillators in receivers, the choice is nearly always a modified form of klystron in which a single resonator is used as both buncher and catcher. It reminds me of the inexperienced driver who knocked down a traffic-control policeman, and on getting into reverse to apologize knocked him down again. In the klystron the reversing is brought about by a negatively charged electrode called the reflector, placed so as to repel the velocity-modulated beam soon after it emerges from the resonator. When the electrons find a fairly high negative voltage ahead of them they hurriedly reverse and pass once more through the resonator, and if things have been successfully arranged they do so in the correct phase for positive feedback and oscillation. The most convenient method of controlling the phase is by adjusting the reflector voltage.

Tuning Facility

One advantage of the reflection klystron is that there is only one resonator to tune, so there is no possibility of the catcher being out of tune with the buncher. The resonator can be provided with one or more screw plugs for varying the internal volume and hence the tuning, or in some models the tuning is varied over a small frequency band by squeezing the cavity. Even without doing anything to the resonator one can vary the frequency of oscillation up to about 1 per cent—which is a considerable number of Mc/s—by varying the reflector voltage, and this is such a convenient method of frequency modulation that f.m. is usually adopted, for example in television microwave links.

In Fig. 6 the two-resonator and reflection klystrons are compared in simplified diagrams, and Fig. 7 shows the arrangement of electrodes in a typical reflection klystron. Note that the resonator is built into the walls of the valve in the same way as the grid and anode of a disk-seal triode.

It must not be imagined that the subject of klystrons has now been covered, for their behaviour is much more complicated than this simplified story would suggest. But we must press on regardless if we are to get in anything about the travelling-wave tube, which is the most difficult to explain of all. There is already a large book devoted entirely to it,

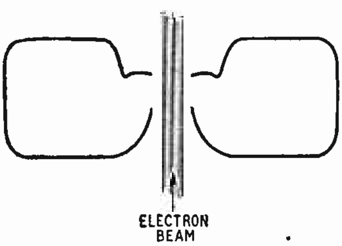
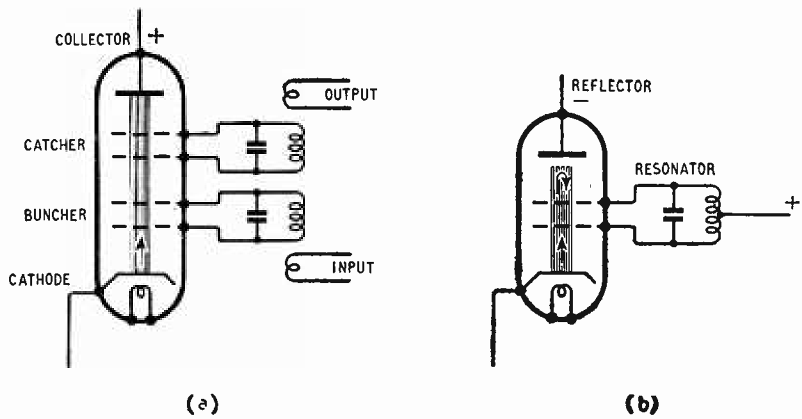


Fig. 5. Section of resonant cavity taking the place of a conventional tuned circuit in the klystron. Oscillatory voltage is developed between the lower and upper holes through which the beam passes. Right: Fig. 6. Diagrammatic comparison of (a) two-resonator and (b) reflection klystrons, the resonators being shown as conventional tuned circuits.



filled with abstruse mathematics. Like the magnetron and klystron, the travelling-wave tube draws on the energy of electrons flying through space at high speed —energy put into them by the steady h.t. supply. Unlike them, it has no resonator or other tuning device, so its functioning is not restricted to a particular frequency or narrow band of frequencies. It is, in fact, a unique and remarkable device—an aperiodic amplifier of microwaves. In the early days the only aperiodic (i.e., untuned) amplifier was the resistance-coupled kind, and it was effective only for audio frequencies, because of stray capacitance, especially Miller effect. With the development of high g_m screened pentodes the frequency band was gradually widened to include r.f. up to 1 Mc/s or so, and, with inductance compensation, higher still, to include the whole television v.f. band. But the wider the band the lower the amplification that can be obtained per stage. At still higher frequencies the effect of stray capacitance is so devastating that it can only be overcome by merging it into a tuned circuit, and of course that is effective only at and near the frequency to which it is tuned. As one gets beyond the v.h.f. band it becomes increasingly difficult to obtain any amplification at all, even with tuning—hence the strenuous efforts made in disk-seal triodes and klystrons. So the travelling-wave tube, which reintroduces aperiodic amplification in the s.h.f. band, of all frequencies, really is quite an astonishing device. The CV2188, for example, at a fixed adjustment gives 15-19 db gain at all frequencies between 3,000 and 4,600 Mc/s simultaneously—a bandwidth of 1,600 Mc/s!

The reason why the magnetron and klystron cannot do this, you remember, is that the d.c. power of the electrons is converted into alternating power by careful *timing* or synchronization effected by tuned circuits, just as in a watch the steady power of the mainspring is converted into regular pulses by the action of its "tuned circuit," the balance wheel. The magnetron, as at present known, is unsuitable for amplification, so can be left out of the comparison; the klystron, as we have just gathered, needs a tuned circuit to control the timing of the bunches of electrons and thereby apply their energy to the second—or the same—tuned circuit at the right moments to develop oscillations of greater amplitude. The travelling-wave (t-w) tube works on a different principle, for it makes use of the *speed* of waves, which is practically the same at all frequencies. Instead of the electrons being made to alternate in time they are made to alternate in distance, running alongside the waves and feeding them with energy continuously. This process is difficult to visualize in detail, but I think one can fairly easily get a rough idea of it, once the principle of energy transfer from flying electrons has been accepted.

In a klystron each electron comes under the influence of the bunching voltage only during the fleeting moment when it is actually passing between the fixed buncher grids. This period has to be kept very brief; otherwise the phase of the voltage would have time to change substantially, or even reverse, while the electron was still there. In the t-w tube it is kept under the influence during most of its journey, for the accelerating or retarding field is made to run along with it, and by so doing to maintain the correct phase all the time. When signals are sent along an ordinary waveguide or transmission line an electric field made in the signal pattern runs along it. But as the speed is not far short of the speed of electromagnetic waves in space ("the speed of light") an enormously high voltage would be needed to make the electrons keep up with it. With reasonable voltages, an electron beam travels at about one-tenth this rate, so the solution is to slow the signal waves down to that. This is very simply done by passing them along a wire wound into a helix (a long single-layer spaced-turn coil) so that the length of the helix is about one-tenth the length of the wire. The signal to be amplified is introduced at one end of the helix, starting a wave moving along it. At the same end of the tube is an electron gun, shooting a beam along the tube inside the helix.

Fig. 8(a) shows diagrammatically a length of the helix in section, in which the electron beam and the signal are supposed to be travelling from left to right. For simplicity let us assume that the signal is a sine wave, the voltage along the helix at the instant considered being as shown in Fig. 8(b). The positive and negative peaks are marked along the helix, so at this instant the electric field inside the helix is tending to move

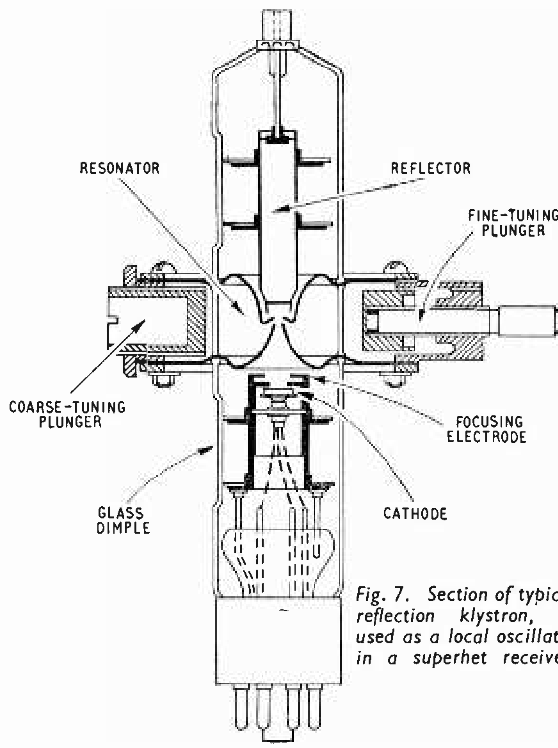


Fig. 7. Section of typical reflection klystron, as used as a local oscillator in a superhet receiver.

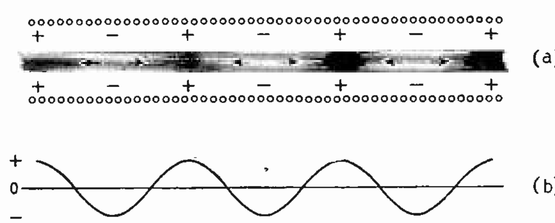


Fig. 8. Diagram representing at (a) the helix of a travelling-wave tube in section, with the electron beam passing through it from left to right. The wave potentials on the helix at the moment selected are shown at (b), and the resulting electric fields inside the helix tend to retard or accelerate the electrons in the beam as shown by the arrows, causing them to bunch (indicated by shading).

the electrons in the directions shown by the arrows. This movement, of course, is superimposed on the high-speed flow from left to right. Since the h.t. voltage has been adjusted to make this flow more or less keep step with the signal along the helix, the local attractions for the electrons are maintained all the way along, and so the electrons increasingly pile up in some places and thin out in others, as indicated by the shading. In other words, continuous bunching is occurring all along the tube.

Now the original unbunched electron stream was simply d.c., having no ability to affect the a.c. signals in the helix. But the bunched stream, which can be regarded as a series of positive and negative charges superimposed on the d.c., inevitably does induce signals in the helix, of the same wavelength as the bunching signal. While it is true that this original signal must have given up some of its energy to the electrons to make them bunch, this energy is very small compared with the energy of the bunches moving along at high speed. If the h.t. voltage responsible for their high speed is adjusted so that the phase of the signal induced by them is suitable, it builds up the original signal so that when it emerges from the helix it is stronger than when it went in. Which, of course, is exactly what is wanted.

As one would expect, the voltage needed to obtain maximum amplification is quite critical, and must be obtained from a stabilized supply. For if the speed of the electrons were much different from that of the signal along the helix they would be alternately bunched and debunched as they came into and out of step.

Obviously the electron stream must be kept to a straight and narrow path all the way through the helix, and this is a different matter from focusing in a cathode-ray tube, where it doesn't matter much if the beam spreads out a bit in the middle so long as it is well focused when it arrives at the screen. Besides a first and second anode system to get the electrons off to a good start, a strong magnetic field is provided all the way, as shown in Fig. 9, which is a simplified section of a t-w tube.

As not very much has been published about these tubes, here are a few details of the CV.2188 used in the 250-mile chain of microwave links from Manchester to Kirk O'Shotts, made by Standard Telephones and Cables, Ltd.* This is the first regular service in the world to make use of these tubes. Each repeater station on the route receives signals in the 4,000 Mc/s band from the previous station, converts them to 60 Mc/s i.f. for amplification, and then converts them back to the 4,000 Mc/s band (but 37 Mc/s different from the received frequency) for re-transmission. The output from the frequency changer is not enough, so the duty of the t-w tube is to raise it from 25 milliwatts to about 1.5 watts. The second anode and the helix are earthed; the cathode is kept at −3,000 V, the first anode at −1,800 V, and the collector at +50 V (to prevent secondary electrons from leaving). Total current is about 14 mA (just over 40 watts), of which the first anode hardly gets any, and the helix only about 1 mA. So most is received by the collector, which is surrounded by a forced-air cooler. The helix, wound 19 turns per inch, has an inside diameter of 0.13in, and the beam diameter is

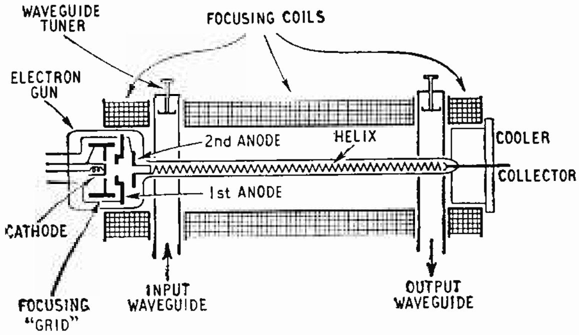


Fig. 9. Simplified section of travelling-wave tube with waveguides and focusing electromagnet in place.

0.09in. The average tube life is over 3,000 hours; the senility of a tube can be read off from the supply voltage stabilizer, which is arranged to raise the anode voltage automatically to offset the effects of old age.

For an American type of tube it is claimed that an output of 10 W is obtained in the 6,000 Mc/s band with 25 db gain, using 1,200 V. And for a receiving type the gain is 15 db to 0.5 mW, with a noise factor of 10 db, using 600 V 0.5 mA. (I can almost hear somebody remarking that travelling-wave tubes are only in their infancy!)

Summing Up

And now for a final summing up of microwave valves.

Disk-seal valves.—They persuade ordinary valve principles to work at these unaccustomed frequencies by dint of extraordinary feats of manufacture. They both oscillate and amplify, but performance of even a modest order ceases above about 4,000 Mc/s, and unless some wonderful new technique is devised there seems to be little scope for substantially increasing either the performance or the frequency. Where it is sufficient to do the job it has the advantages of simplicity and small size.

Magnetrons (resonant-cavity type).—Unsuitable for amplification or low-power oscillation or any sort of gradual modulation, but unrivalled for high-power oscillation, especially when pulse-modulated as in radar. Simple and robust, and available for any of the microwave bands, but frequency not easily varied by more than a little, and prone to oscillate at more than one frequency at a time.

Klystrons.—Can be used as oscillators and (if of two-resonator type) as amplifiers, but in latter role are noisy. Particularly suitable as low-power oscillators, especially in superhet receivers, but can be designed for power output rivalling magnetrons in continuous rating and unlike magnetrons they lend themselves very well to frequency modulation.

Travelling-wave tubes.—Oscillate and amplify, but compare unfavourably with the others for oscillation. Unique in amplifying almost equally over very wide frequency band. Larger and more complicated than disk-seal triode or klystron, but in addition to wide-band characteristics, they beat the triode in performance and the klystron in noise-factor.

So we see that while for some purposes there may be room for choice from among these four types, for the most part each has its own job or jobs at which it does best.

* "The Travelling-Wave Tube as Output Amplifier in Centimetre-Wave Radio Links," D. C. Rogers, *Proc. I.E.E.*, Part III, May, 1953, p. 151. "British TV Relay Uses Travelling-Wave Tubes," D. C. Rogers and P. F. C. Burke, *Electronics*, June, 1953, p. 156.

Inexpensive Megohmmeter

An Instrument for Measuring Resistance Over the Range 0.1 to 10,000 MΩ

By H. E. STYLES, B.Sc.

DURING the course of experimental work, a need is often felt for equipment by means of which insulation resistance may be checked or resistances of the order of hundreds of megohms measured with reasonable accuracy. Such measurements cannot be made with the simple types of a.c. bridges normally available to most people, whilst d.c. tests usually require very sensitive, delicate and expensive measuring instruments or somewhat elaborate amplifying equipment.

This article shows how a simple, inexpensive and robust instrument may easily be constructed so as to permit accurate measurement of resistances within the range of 0.1 to 10,000 megohms or more under an applied potential of about 100 volts. In addition the instrument enables insulation resistance to be tested at about 500 volts, though at this voltage resistance measurements may be less accurate as they are not independent of variations in mains supply voltage. The same instrument can, with very little complication, be made to serve as an audio-frequency signal generator capable of producing any desired frequency from 0.25 to several thousands of cycles per second. Only one component, a one-megohm resistor, needs to have a precisely known value and calibration of the equipment is a matter of extreme simplicity.

The instrument is based upon the very simple circuit shown in Fig. 1 which will be recognized as the most elementary form of saw-tooth oscillator. Capacitance C charges through resistance R to the striking potential of the neon discharge tube S at which stage the capacitance becomes rapidly discharged until its potential falls to that at which tube S becomes extinguished. The potential of C then rises again and the cycle repeats indefinitely. Pulses of current are thereby produced in the circuit comprising C and S, and these pulses may readily be made evident by inserting a low resistance telephone receiver at the point marked X in Fig. 1.

The frequency at which pulses are generated will depend upon the characteristics of the neon tube S, the values of C and R and the applied voltage E which must, of course, be greater than the striking voltage of S. For any particular discharge tube, the frequency of the pulses will be inversely proportional to the product of C and R and directly proportional to E. If the latter be maintained constant, it is evident that for any chosen value of C, determination of the frequency of oscillation with different resistances at R will provide a means of accurately comparing their values.

An appropriate constant voltage can readily be achieved by means of the circuit shown in Fig. 2, which incorporates two additional discharge tubes as voltage stabilizers. Provided the latter are operated at a suitable current, the frequency of oscillation produced by this circuit can be made independent of the supply voltage within quite wide limits. By suitable choice of capacitance the frequency of oscillation can be kept within easily countable limits for values of resistance ranging from one to 10,000 megohms. For purposes of signal generation, fine control of frequency can readily be obtained by means of the slightly modified circuit shown in Fig. 3.

Fig. 4 shows the circuit of the final instrument based upon the foregoing considerations. In order to render the equipment capable of being used for testing earthed circuits, power is taken from the mains via a double-wound transformer. The latter can, however, be of very small size, as it is required to supply only two or three watts, and the author has successfully employed one in which the primary and h.t. secondary windings are wound with 44 s.w.g. and 47 s.w.g. wires respectively.

An EB34 (VR54) valve is employed as a voltage doubling rectifier and with a 200-volt input this provides a peak output of about 560 volts d.c. The valve operates under conditions much more arduous than those for which it is rated, but no difficulties have been experienced on this account. The heater winding of the transformer is left floating in order to minimize potential differences between it and the valve cathodes, whilst the internal and external screens of the valve are left unconnected.

Resistances R_1 and R_2 together should be such as to allow a current of about 1.5 mA. to flow through the stabilizer tubes S_1 and S_2, for which VS70s are used. Under such conditions of operation a variation of ± 10 % in mains supply voltage produces no detectable change in frequency of oscillation.

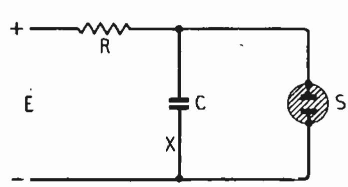


Fig. 1. Basic circuit of the megohmmeter.

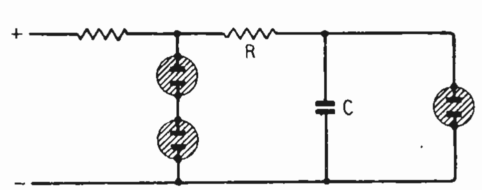


Fig. 2. Stabilized h.t. supply for the megohmmeter.

Switch A enables the stabilizer tubes to be disconnected so as to raise the test voltage to the peak value available from the rectifier. This voltage is, of course, not independent of mains fluctuations and may also vary according to the current passed by the resistance under test. For these reasons resistance measurements at the higher test voltage can only be regarded as approximate, but this is all that is normally required for insulation test purposes.

With switch A closed a stabilized potential of about 200 volts is maintained across tubes S_1 and S_2, so that, as the striking voltage of the oscillator tube S_3 is about 100 volts, resistance measurements are conducted at an applied potential of about 100 volts. It is important to know this as the resistance of some materials varies considerably with the applied voltage.

Switch B is the normal on-off switch fitted to the one-megohm volume control potentiometer R_3 and when closed permits the latter to be employed to vary the frequency of oscillation produced by resistance R_4 in conjunction with any capacitance selected by means of switch C. If the instrument is not required for use as a signal generator the switched potentiometer can, of course, be omitted.

Resistance R_4 must be of accurately known value and such as will produce, in conjunction with a one-microfarad capacitance, an oscillation of easily countable frequency. One megohm will probably be found suitable but differences between discharge tube characteristics may necessitate choice of a somewhat different value. A CV188 tube is employed for the oscillator S_3 though another VS70 could be used in this position. The former tube, however, appears to exhibit greater differential between striking and extinction voltages and therefore produces pulses of greater amplitude, whilst the use of a distinctive tube for the oscillator serves to obviate any possibility of inadvertently exchanging it with one of the stabilizer tubes.

The four capacitors connected to switch C have to withstand only the striking voltage of the oscillator tube, but their insulation must be beyond suspicion and components of high voltage rating are therefore desirable. The two capacitors of lower value can well be of the mica dielectric variety but good quality paper insulated capacitors may be used. Switch C must also be free from detectable leakage, one having ceramic insulation being preferable, whilst the oscillator tube base and holder must also be free from surface leakage in order to avoid shunting the capacitors with a resistance which would prevent them from charging at a correct rate. Switch B must be of good quality also, but in this case any leakage will be made evident during initial tests with the instrument.

Needless to say, the test terminals themselves must be very well insulated. The author employs a bakelite instrument panel upon which are mounted the test terminals. Surface leakage between these terminals could readily be detected at 500 volts, using the smallest capacitance, and it was therefore necessary to eliminate the effect of this by surrounding the terminal connected to the oscillator anode by a guard ring* (on both sides of the panel) connected to the oscillator cathode. Surface leakage currents are thereby by-passed and prevented from charging the capacitance and producing false indications. Similar precautions may be necessary to eliminate surface leakage effects when testing high resistances and a guard ring terminal connected to the oscillator cathode is provided for this purpose.

Calibration

Calibration of the instrument is effected as follows :– The test terminals are short-circuited, switch A is closed, switch B is opened and switch C is set so as to connect the one-microfarad capacitance into circuit. The number of clicks produced by the telephone receiver in exactly one minute is carefully determined. Let this number be N. Then if an unknown resistance, R, connected between the test terminals produces, in conjunction with the one-microfarad capacitance, n clicks per minute, its resistance will be given by the formula : $R=\frac{N}{n}R_4-R_4$. If R_4 is made exactly one megohm, this formula reduces to $R=\frac{N}{n}-1$ megohms.

With other values of capacitance the formula becomes : $R=\frac{FN}{n}R_4-R_4$ where F is the ratio of the capacitance of the $1.0\text{-}\mu F$ capacitor to that of the capacitor selected for use. If the capacitors employed

* For example, see "Measuring High Resistance," by M. G. Scroggie. *Wireless World*, June, 1952, pp. 236-238. Ed.

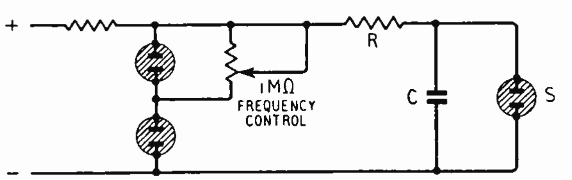
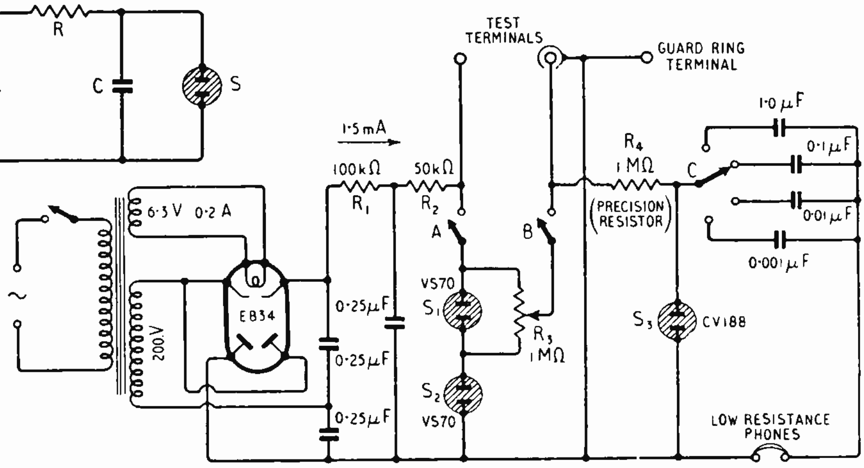


Fig. 3. Frequency control for a neon tube oscillator.



Right : Fig. 4. Complete circuit of the megohmmeter high resistance test set. The components mentioned in the text are given appropriate references in addition to their values.

possess precisely correct values, rotation of switch C will correspond to successive tenfold multiplication of resistance values. There is however no need to employ precision capacitors as the appropriate multiplying factors can easily be determined as follows.

Select a resistance which produces a fast but easily countable frequency with the 0.1-μF capacitor. Count the number of clicks per minute. Change over to the 1.0-μF capacitor and repeat the count. The ratio of these two counts will then give the desired multiplying factor to be applied to readings obtained with the 0.1-μF capacitor in circuit. The 0.1-μF capacitor can similarly be compared with the 0.01-μF component and an appropriate factor for the latter derived. This procedure is repeated for the 0.001-μF capacitor, the only difficulty being to find resistances of sufficiently high value for the purpose. Specimens of poor insulating materials such as wood, fibre and cardboard may be employed provided that checks are made to ensure their resistance remains constant during the course of the tests.

The last stage of the calibration procedure consists of determining the multiplying factor to be applied to all readings obtained when the test voltage of 500 is used. For this purpose a resistance of about 5 megohms should be connected across the test terminals and, using the 1.0-μF capacitor, counts taken with switch A in both the closed and open positions. The ratio of these counts gives the required factor for obtaining approximate resistance values at the higher test voltages In carrying out this particular calibration care should be taken to employ a resistor unlikely to exhibit any marked change in resistance when the applied voltage is raised from 100 to 500. A series of five separate one-megohm resistors should be satisfactory in this respect.

Careful tests have shown that for resistances up to some twenty megohms the instrument is capable of an accuracy sufficient to give results within 1% of the true values and it is believed that this accuracy holds good at higher values. The stability of the equipment can always be checked by taking a count with the test terminals short-circuited. Any change observed may be due to alteration in discharge tube characteristics with age but is more likely to be due to alteration in the comparison resistance R_4 or to accumulation of slightly conducting films on the insulation of various components. No trouble of this kind has yet been experienced as the instrument can be housed in a tightly closed box, there being no appreciable evolution of heat.

Single-sideband Receiver

THE single-sideband (s.s.b.) method of transmission is gaining in popularity on many long-distance short-wave radio circuits since it possesses several distinct advantages over the older double-sideband system. For example, the signal/noise ratio is better; less bandwidth is required for a comparable service; there is a marked freedom from non-linearity distortion due to multi-path transmission and greater traffic-handling capacity, since both sidebands can be employed independently.

In view of these advantages, more than usual interest attaches to the development by the equipment division of Mullard of an independent sideband communications receiver known as the Type GFR552. It covers 4 to 30 Mc/s in four ranges and is intended for the following types of reception:—

1. A3—normal double sideband.
2. A3a—single-sideband with a pilot carrier 16 db below the peak sideband power.
3. A3b—independent sideband with pilot carrier 26 db below the peak power of either sideband.

The receiver is a double superheterodyne with intermediate frequencies of 3.1 Mc/s and 100 kc/s respectively. It is designed for continuous use on long-distance circuits for telephone and telegraph traffic and provides for simultaneous and independent reception of four telephone channels of 3-kc/s bandwidth or two of broadcast quality (6 kc/s). Alternatively each sideband can be used to carry several audio-frequency telegraph channels.

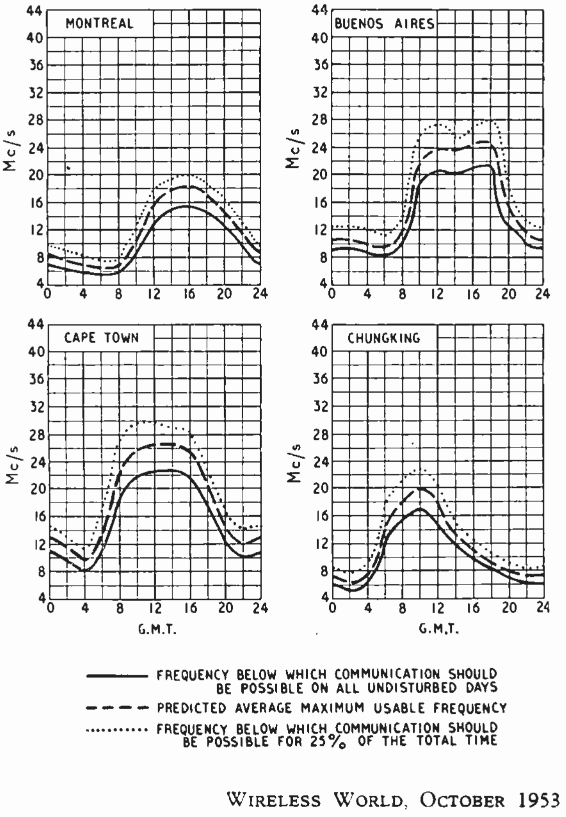
The receiver is assembled in an enclosed rack-type cabinet measuring 7 ft high, 24 in wide and 26 in deep. The makers are Mullard, Ltd. (Equipment Division), Century House, Shaftesbury Avenue, London, W.C.2.

Short-wave Conditions

Predictions for October

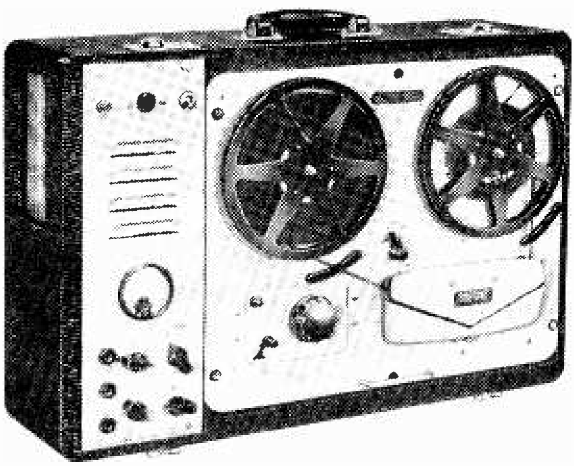
THE full-line curves given here indicate the highest frequencies likely to be usable at any time of the day or night for reliable communications over four long-distance paths from this country during October.

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



VORTEXION TAPE RECORDER

FEATURES WORTH NOTING . . . . . .



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 30 lb.

PRICE, complete with WEARITE TAPE DECK £84 0 0

★ The noise level is extremely low and audibly the hum level and Johnson noise of the amplifier and deck are approximately equal. Only 25% of this small amount of hum is given by the amplifier alone.

★ 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.

★ A heavy mu-metal shielded microphone transformer is built in for 15-30 ohms balanced and screened line, and requires only 7 micro-volts approximately to fully load.

★ The .5 megohm input is fully loaded by 18 millivolts and is suitable for crystal P.U.'s, microphone 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.

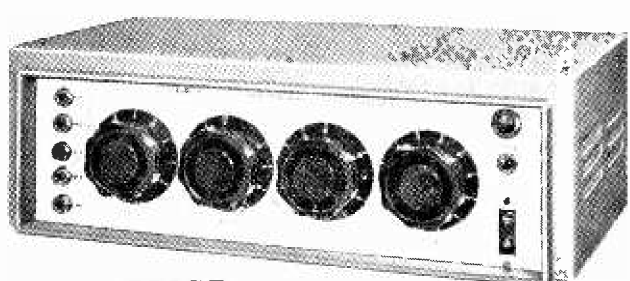
★ Facilities are provided for using the amplifier alone and using power output or headphones while recording or to drive additional amplifiers.

★ The unit may be left running on record or play back even with 1,750 ft. reels with the lid closed.

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

The FOUR CHANNEL ELECTRONIC MIXER

is almost essential for the professional or semi-professional where a number of different items have to be mixed on one tape recording.
It is recommended by a number of tape recorder manufacturers for this purpose.
Any normal input impedance can be supplied to order, balanced or unbalanced, the standard being 15-30 ohms balanced.
The normal output is 0.5 volt on 20,000 ohms or less, but 600 ohms is available as an alternative.
The steel stove enamelled case is polished and fitted with an engraved white panel suitable for making temporary pencil notes.
An internal screened power pack and selenium rectifier feed the five low noise non-microphonic valves.
Used in many hundreds of large public address installations and recording studios throughout the world.



PRICE
£36.15.0

Manufactured by

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

Telephones: LIBerty 2814 and 6242-3 Telegrams: "Vortexion, Wimble, London."

Converter for 200 kc/s

Unusual Application of Crystal Control

By C. B. RAITHBY*

A VERY large number of communication receivers of both American and British manufacture do not include the long waveband and cannot therefore receive Droitwich on 200 kc/s.

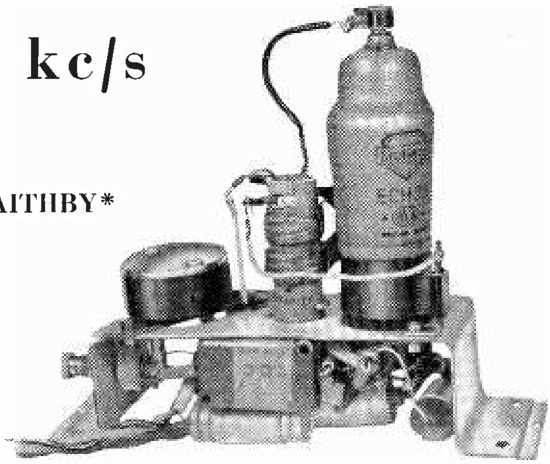
This is a disadvantage to both the "all-wave" listener and the transmitting amateur. For the former, if he wants to listen to the B.B.C. Light programme reception on 1,214 kc/s is often unsatisfactory in many areas. For the latter, the 200-kc/s transmission, if available, provides an excellent means of checking the calibration of oscillators.

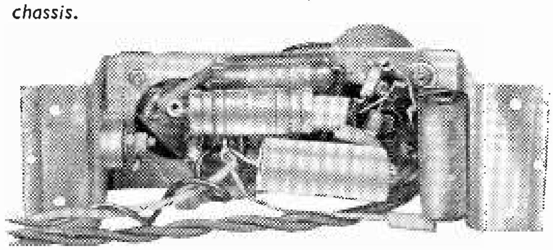
The converter described here provides a simple means of receiving Droitwich on 200 kc/s on any reasonably well-screened short-wave receiver.

An ECH35 valve is used as a mixer with a crystal-controlled oscillator. The coil L_1L_2 is a Wearite type PA1 but any equivalent coil is suitable.

The advantage of the design is that a wide range of crystals may be used including available ex-Government surplus. Crystal frequencies ranging from 3 to 10 Mc/s have been found satisfactory. Some actual frequencies used are 3.5 Mc/s (with the main receiver at 3.3 or 3.7 Mc/s), 8 Mc/s (with the receiver at 7.8 or 8.2 Mc/s), 10 Mc/s (with the main receiver at 9.8 or 10.2 Mc/s). A receiver frequency occupied by a very strong station should be avoided. Fortunately the input to the receiver from the converter is so great that the former's gain is greatly reduced by the a.g.c. action. No such difficulties were encountered on the frequencies mentioned.

If the converter is to be located inside a communication receiver, then its construction and shape will depend on the space available. In the one described and illustrated a small brass chassis, approximately $4\frac{1}{2} \times 1\frac{3}{4} \times 1\frac{1}{4}$ in is used. The layout is not critical and any reasonable layout should prove satisfactory. If space is very limited a miniature frequency changer valve such as the UCH42 may be used, with appropriate circuit changes, instead of the ECH35. A length of coaxial cable conveys the converter output from the feed-through insulator on the left to the receiver aerial socket. If the converter is located within the receiver the power supplies of 250 volts d.c. and 6.3 volts a.c. can probably be taken from the existing supply unit. At 250 volts h.t. the current consumption is 10 mA, but satisfactory operation can be obtained at 130 volts, $3\frac{1}{2}$ mA if economy is essential due to possible overloading of the receiver's power supply circuit.



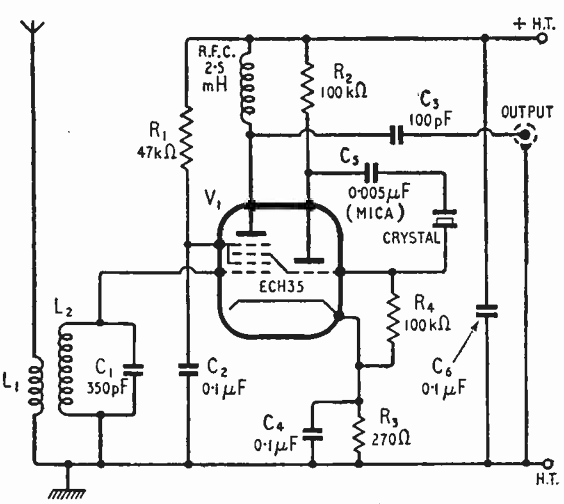


Crystal-controlled converter described in the text fitted with the ECH35 valve and below, an underside view of the chassis.

When this is not possible a small separate power unit will be necessary. The converter can be used apart from the receiver and quite satisfactory operation has been obtained with about 30 ft of coaxial cable joining the two.

In this unit capacitor C_1 is fixed and of 350 pF. If preferred a combination of fixed capacitor and parelleled trimmer may be used. C_1 is not very critical, however. It is suggested 350 pF be used as a start. If the receiver has an "S" meter various values can be tried until the maximum reading is obtained. Alternatively, temporarily connect a normal variable capacitor of 0.0005 μF maximum across L_2 and adjust for optimum setting, remove, measure the capacitance on a bridge and connect in a fixed capacitor(s) of this value.

To put the converter into operation, connect the receiver's aerial socket to the converter and the converter's output terminal to the receiver. Insert a suitable crystal in the converter, switch on and tune the receiver to the crystal frequency to check that it is oscillating. Then tune the set 200 ks/s higher or lower for Droitwich. Select the better of the two.



Circuit diagram of the crystal-controlled long-wave converter.

* Amateur radio station G8G1.

Valve Matching Using Resistors

Analytical and Experimental Methods of Equating Characteristics

OCCASIONALLY circumstances arise when two or more valves having as nearly identical characteristics as possible are required. Perhaps a valve voltmeter is being built in which drift is to be minimized[1]; perhaps the mathematics of a novel circuit is simplified by the assumption that all of the valves have identical parameters.[2] To meet the need, negative feedback might possibly be applied to reduce unwanted effects,[3] or the required valves may be specially selected[4] from a number of the same type.

The home experimenter's valve stock may not be large enough to allow making a good selection, and the experimenter may wish to avoid the complication of negative feedback with its resulting reduction of gain. An ideal way out of the difficulty would be to modify the characteristics of the available valves, reducing their parameters to a common level. This idea can in fact be applied with a fair degree of success by using suitable resistances in conjunction with the valves. The matching is not perfect and does not take account of parameter changes caused by ageing or by fluctuations of heater voltage. Nevertheless the method is simple in principle and application.

Fig. 1 shows an elementary amplifier modified by the inclusion of the resistor R_1 between the valve and its load impedance Z. From simple theory the alternating output voltage V_2 for an alternating input voltage V_1 is

$$V_2 = -\frac{\mu_1 V_1 Z}{r_{a1} + R_1 + Z} \quad .. \quad (1)$$

where μ_1 and r_{a1} are the amplification factor and valve impedance respectively, the minus sign indicating the phase relationship between the input and output voltages. The same output would be obtained, in the absence of R_1 if the valve had the same amplification factor μ_1, but an impedance equal to $(r_{a1} + R_1)$. In accordance with the relationship $\mu = g_m r_a$, the mutual conductance of the new valve would be

$$\frac{g_{m1}}{(1 + R_1/r_{a1})}$$

In Fig. 2, the amplifier is modified by the resistance R_2 in parallel with the valve. The expression for the alternating output voltage is now

$$V_2 = -\frac{\left(\frac{1}{1 + r_{a2}/R_2}\right)\mu_2 V_1 Z}{\left(\frac{r_{a2}}{1 + r_{a2}/R_2}\right) + Z} \quad .. \quad .. \quad (2)$$

where μ_2 and r_{a2} are the amplification factor and valve impedance respectively.

Thus the combination of valve and parallel resistor behaves as a new valve with an amplification factor

$$\mu_2\left(\frac{1}{1 + r_{a2}/R_2}\right)$$

and impedance $r_{a2}\left(\frac{1}{1 + r_{a2}/R_2}\right)$

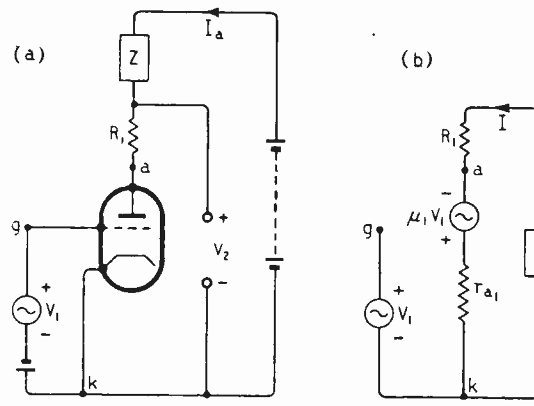
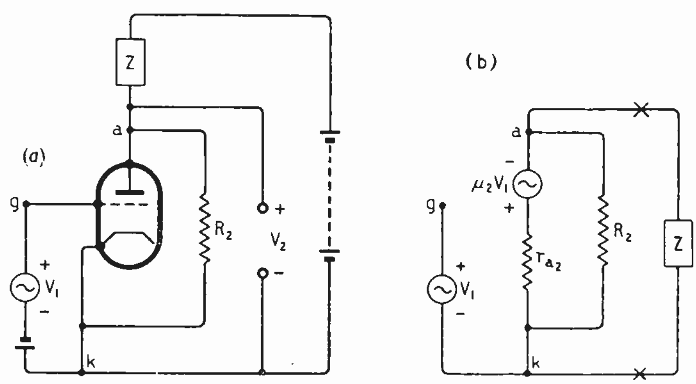


Fig. 1. (a) Simple amplifier, (b) a.c. equivalent circuit.



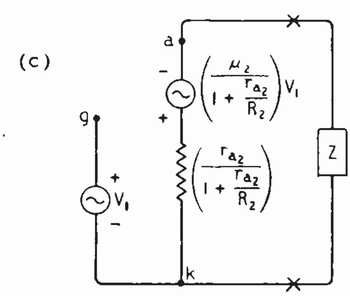


Fig. 2. (a) Simple amplifier, (b) a.c. equivalent circuit, (c) alternative equivalent circuit derived from (b).

By H. V. HARLEY, B.Sc.*

This may also be easily seen by applying Thevenin's Theorem to the equivalent circuit of Fig. 2(b). The mutual conductance is g_{m2}, and is not altered by the parallel resistance.

In a like manner the parameters of the "equivalent valve" made from a true valve with both series and parallel resistances can be found. Fig. 3 tabulates the results.

The effective parameters of the combinations depend both on those of the valve and on the resistances. Suitable choice of the resistances makes it possible to derive combinations with similar parameters, even though the valves themselves are dissimilar. Thus for equivalence of Figs. 1 and 2 the parameters of the one combination are made equal to those of the other.

Equating the amplification factors we have

$$\mu_1 = \frac{\mu_2}{(1 + r_{a2}/R_2)} \quad \ldots \ldots \ldots \ldots \quad (3)$$

and for equivalent impedances

$$r_{a1}(1 + R_1/r_{a1}) = \frac{r_{a2}}{(1 + r_{a2}/R_2)} \quad \ldots \ldots \quad (4)$$

The required values of R_1 and R_2 may thus be found

* Department of Electrical Engineering, University College of North Wales.

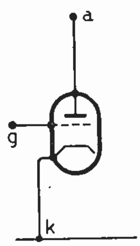
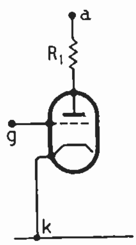
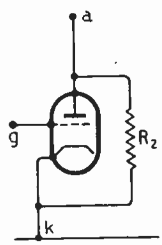
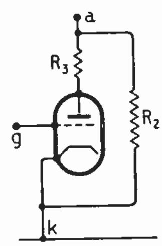
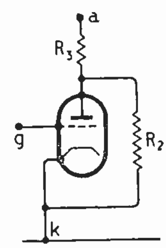
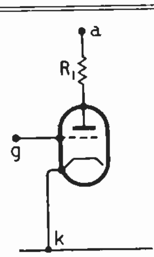
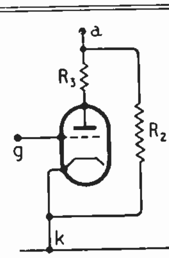
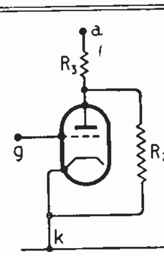
	1	2	3	4	5
CIRCUIT OF EQUIVALENT VALVE					
AMPLIFICATION FACTOR	μ	μ	$\frac{\mu}{\left(1+\frac{r_a}{R_2}\right)}$	$\frac{\mu}{\left(1+\frac{r_a}{R_2}+\frac{R_3}{R_2}\right)}$	$\frac{\mu}{\left(1+\frac{r_a}{R_2}\right)}$
IMPEDANCE	r_a	$r_a\left(1+\frac{R_1}{r_a}\right)$	$\frac{r_a}{\left(1+\frac{r_a}{R_2}\right)}$	$\frac{r_a\left(1+\frac{R_3}{r_a}\right)}{\left(1+\frac{r_a}{R_2}+\frac{R_3}{R_2}\right)}$	$r_a\left[\frac{R_3}{r_a}+\frac{1}{\left(1+\frac{r_a}{R_2}\right)}\right]$
MUTUAL CONDUCTANCE	g_m	$\frac{g_m}{\left(1+\frac{R_1}{r_a}\right)}$	g_m	$\frac{g_m}{\left(1+\frac{R_3}{r_a}\right)}$	$\frac{g_m}{\left[1+\frac{R_3}{r_a}\left(1+\frac{r_a}{R_2}\right)\right]}$

Fig. 3. Properties of "equivalent valves."

Fig. 4. Equivalence of valve-resistance combinations.

	1	2	3
CIRCUIT CONFIGURATION			
PARAMETERS OF VALVES ALONE	$\mu_1 : r_{a_1} : g_{m_1}$	$\mu_2 : r_{a_2} : g_{m_2}$	$\mu_3 : r_{a_3} : g_{m_3}$
CONDITIONS FOR A.C. EQUIVALENCE WITH CIRCUIT OF COLUMN 1		$R_1 = \mu_1\left(\frac{1}{g_{m_2}} - \frac{1}{g_{m_1}}\right) + R_3\left(\frac{\mu_1}{\mu_2}\right)$	$R_1 = \mu_1\left(\frac{1}{g_{m_3}} - \frac{1}{g_{m_1}}\right) + R_3$
		$R_2 = \left(\frac{\mu_1\mu_2}{\mu_2-\mu_1}\right)\frac{1}{g_{m_2}} + R_3\left(\frac{\mu_1}{\mu_2-\mu_1}\right)$	$R_2 = \left(\frac{\mu_1\mu_3}{\mu_3-\mu_1}\right)\frac{1}{g_{m_3}}$

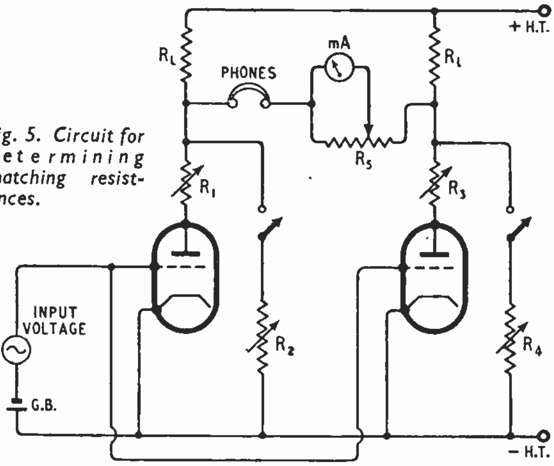


Fig. 5. Circuit for determining matching resistances.

simply by solving equations (3) and (4) for R_1 and R_2, giving

$$R_1 = \mu_1 \left(\frac{1}{g_{m2}} - \frac{1}{g_{m1}} \right) \quad .. \quad .. \quad .. \quad (5)$$

$$R_2 = \left(\frac{\mu_1 \mu_2}{\mu_2 - \mu_1} \right) \frac{1}{g_{m2}} \quad .. \quad .. \quad .. \quad (6)$$

If one excludes negative resistances and negative mutual conductance valves, equations (5) and (6) can only be satisfied for $g_{m1} \geqslant g_{m2}$ and $\mu_2 \geqslant \mu_1$ (if $\mu_2 = \mu_1$ then $R_2 = \infty$, i.e. this resistance is not needed). Thus the parallel resistance must be associated with the valve having the larger amplification factor and the series resistance with the valve having the larger mutual conductance.

It can be seen that the circuit arrangements of Figs. 1 and 2 could not have been matched had both the amplification factor and mutual conductance of one valve been greater than the corresponding parameters of the other. For such a case, a more general "equivalent valve," such as in Fig. 3, columns 4 or 5, would be necessary. Fig. 4 details the more general conditions for equivalence of the valve-resistance combinations.

Depending upon which of the valves has the lower mutual conductance, either R_1 or R_3 of Fig. 4 may be zero. The g_m of the matched pair then equals that of the valve with the lower mutual conductance. By restricting the parallel resistance to the valve with the higher μ, the amplification factor of the matched pair is made equal to that of the valve with the lower μ. Neither mutual conductance nor amplification factor can be increased by adding resistances.

The resistances R_1, R_2 and R_3 of the foregoing results could, of course, be incorporated in the actual amplifier load impedances, and the alternating output voltages could be taken at the correct level from the modified loads. However, it is of interest to examine the effect of the resistances as added in Figs. 3 and 4 on the d.c. characteristics of the combinations.

Let the same linearity of valve characteristics be assumed, as implied in the a.c. equivalent circuit analysis. The current taken by an "equivalent valve" may be found by combining with the true

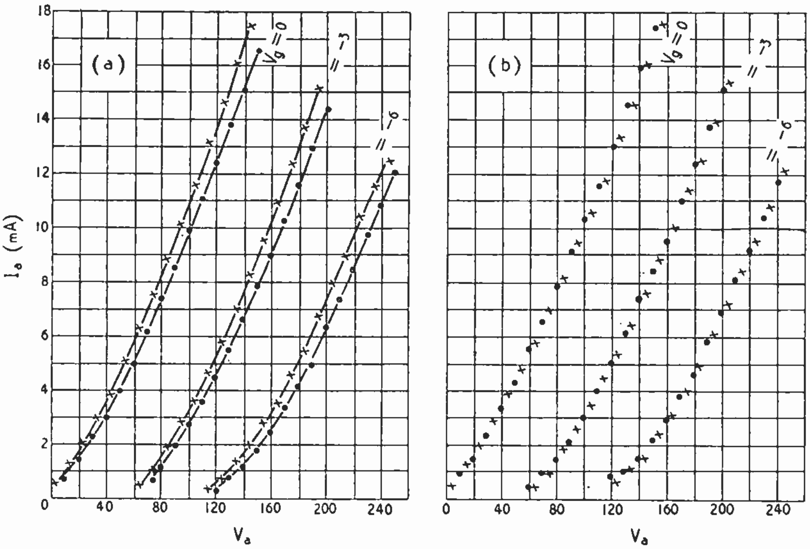


Fig. 6. (a) Anode characteristics of 6SN7 double triode, (b) "anode" characteristics of matched valve-resistor combinations. (× points for one triode section, • points for the other triode section.)

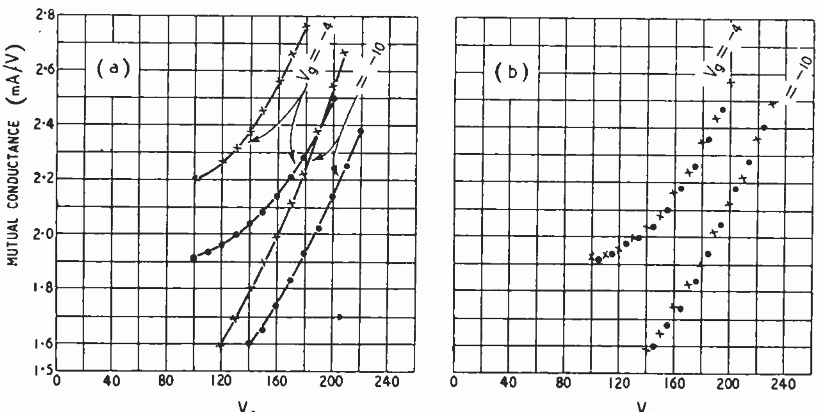


Fig. 7. (a) Mutual conductance curves for KT63 valves alone (strapped as triodes), (b) mutual conductance curves for matched valve-resistor combinations. (× points for one valve or combination, • points for other valve or combination.) The matching resistances were calculated using valve parameters for V_a = 160V and V_g = —6V.

anode current the effects of voltage drops and shunt currents contributed by the added resistors. By so doing, one finds that a further condition has to be satisfied if d.c. equivalence of the valve-resistance combinations is to accompany a.c. equivalence. This condition, which is derived in the appendix, is independent of the added resistances, and can be simply expressed in terms of the valve mutual conductances or amplification factors. Therefore the possibility of obtaining similar d.c. characteristics for a.c. matched combinations depends only upon the characteristics of the valves themselves, and nothing can be done about it by adding resistances. A limited series of experiments with triode valves of like kind has shown, however, that matching of a.c. characteristics may in practice be accompanied by reasonable matching of overall d.c. characteristics. The latter effect is of importance as it affords a means of finding easily the resistances required. The circuit used is that of Fig. 5.

It is assumed at the outset that the valve-resistance combinations, when matched, will behave identically for both a.c. and d.c. Any single mutual characteristic curve of a combination will be defined by the effective anode current corresponding to a particular grid voltage, and by the slope of the characteristic (i.e. by the mutual conductance). Then any two combinations are matched if they have the same mutual conductance and the same standing current for given grid and h.t. voltages.

The resistances R_L of Fig. 5 are equal and of the order of 100 to 500 ohms. R_1, R_2, R_3 and R_4 are calibrated carbon track or wirewound variable resistors, and R_5 is included to protect the milliammeter. The input alternating voltage is obtained from an audio frequency source. Because low values of R_L are used, the alternating voltage across each one of them will be proportional to the g_m of the valve-resistance combination feeding it. Equality of alternating voltage across each R_L, and thus equality of the mutual conductances of the combinations, is achieved by adjusting R_1 or R_3 until the sound in the headphones is a minimum. To keep the mutual conductance of the combinations as high as possible, either R_1 or R_3 should be zero. After being appropriately switched in, R_3 or R_4 is adjusted until the milliammeter reads zero. Slight readjustment of R_1 or R_3 may now be required. When both a.c. and d.c. nulls are obtained, the calibrations of the four resistors give the resistances required to produce matched combinations for the particular h.t. and grid bias voltages obtaining.

Fig. 6 shows the matching achieved between the two sections of a 6SN7 double triode, using the above experimental method. The results of Figs. 7 and 8 were obtained by calculation from the equations of Fig. 4, the valves being KT63s strapped as triodes. It can be seen from Fig. 8(b) how nearly coincidence of d.c. characteristics has followed the a.c. matching. For Figs. 9 and 10 calculated values of resistance were again used, but with valves of more widely differing characteristics.

It is of interest that the valve-resistor combinations

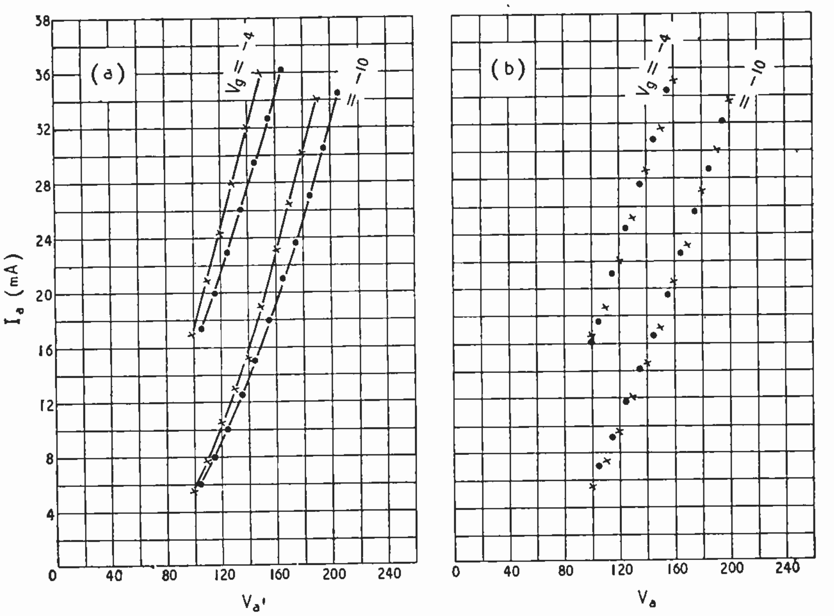


Fig. 8. (a) Anode characteristics of KT63 valves alone (strapped as triodes), (b) "anode" characteristics of matched valve-resistor combinations. (x points for one valve combination, • points for other valve or combination.) The matching resistances were calculated using valve parameters for V_a = 160V and V_g = —6V.

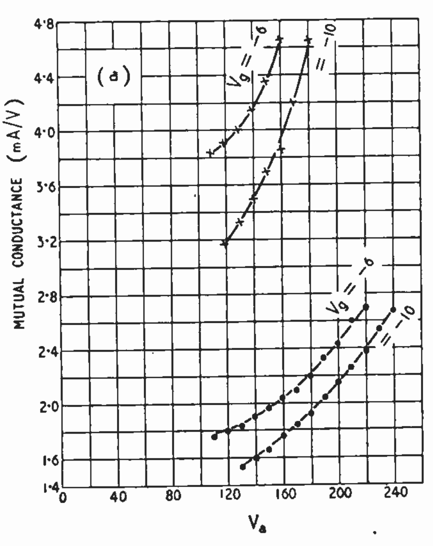


Fig. 9 (a) Mutual conductance curves for one KT63 and one KT66 (both strapped as triodes), (b) mutual conductance curves for matched valve-resistor combinations. (• points for KT63, x points for KT66.) The matching resistances were calculated using valve parameters for V_a = 160V and V_g = —6V.

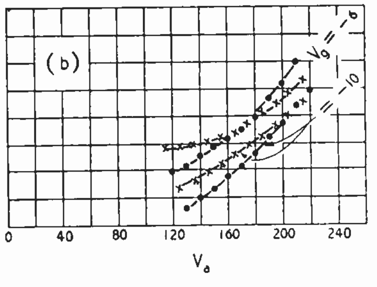
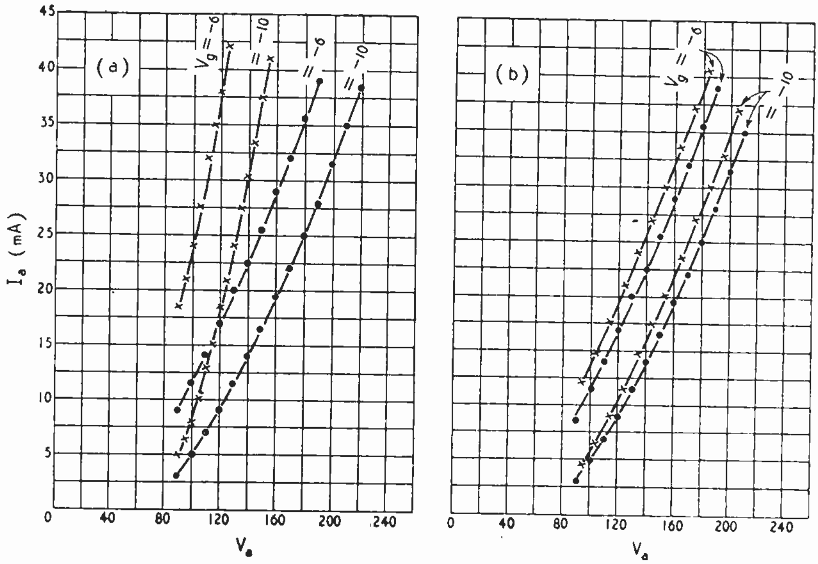


Fig. 10 (a) Anode characteristics of KT63 and KT66 valves alone (both strapped as triodes), (b) "anode" characteristics of matched valve-resistor combinations. (● points for KT63, x points for KT66.) The matching resistances were calculated using valve parameters for $V_a = 160V$ and $V_g = -6V$.



were reasonably matched, even though the parameters of the valves themselves were not constant over the range of operating voltages.

The results presented are for triode valves. In elementary analysis, pentodes are looked upon as constant current devices. To modify the characteristics of a pentode, a rather large resistance might be needed if connected between the anode of the valve and the load, whereas the desired result may better be achieved with an un-bypassed cathode resistor. This, of course, constitutes negative feedback.

APPENDIX

Analysis of D.C. Conditions

Case 1.—The equation of the more linear regions of the anode characteristic curve of a valve is closely approximated by

$$I_a = \frac{1}{r_a}\left(V_a + \mu V_g\right) + k \quad \ldots \quad \ldots \quad \ldots \quad \text{(i)}$$

where I_a is the anode current, r_a and μ the valve impedance and amplification factor respectively, and the constant k is the intercept on the I_a axis of the tangent to the anode characteristic for zero V_g. This constant, k, may be thought of as an additional valve parameter which must be considered when d.c. matching is desired.

Hence for Fig. 11 we may write

$$I_a = \frac{1}{r_{a1}}\left(V_a + \mu_1 V_g\right) + k_1 \quad \ldots \quad \ldots \quad \ldots \quad \text{(ii)}$$

where the subscript $_1$ indicates that the parameters apply to the particular valve in Fig. 11.

$$\text{Also } V_a = V_1' - I_a R_1 \quad \ldots \quad \ldots \quad \text{(iii)}$$

Fig. 11.

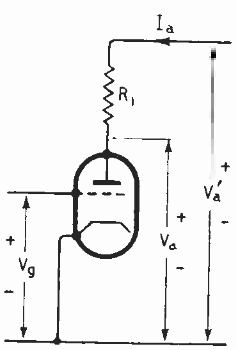
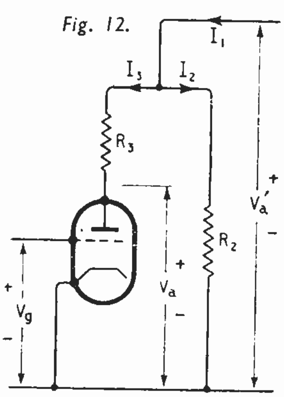


Fig. 12.



From (ii) and (iii)

$$I_a = \left(\frac{1}{r_{a1}(1 + R_1/r_{a1})}\right)\left(V_a' + \mu_1 V_g\right) + \frac{k_1}{(1 + R_1/r_{a1})} \quad \text{(iv)}$$

Comparison of the valve parameters of (i) with those of the valve-resistance combination in (iv) gives the same results as were derived earlier from purely a.c. considerations; see Fig. 4, column 2.

Case 2.—The effective parameters, including the effective value of k, may also be derived for the valve-resistance combination of Fig. 12. Using the suffix $_2$ to denote the parameters of the valve alone, we have by comparison with equation (iv)

$$I_3 = \left(\frac{1}{r_{a2}(1 + R_3/r_{a2})}\right)\left(V_a' + \mu_2 V_g\right) + \frac{k_2}{(1 + R_3/r_{a2})} \quad \text{(v)}$$

Also $\quad I_2 = V_a'/R_2$, and $I_1 = I_2 + I_3 \quad \ldots \quad \ldots \quad$ (vi)

Hence, from (v) and (vi)

$$I_1 = \left(\frac{1 + r_{a2}/R_2 + R_3/R_2}{r_{a2}(1 + R_3/r_{a2})}\right)\left(V_a' + \left(\frac{\mu_2}{1 + r_{a2}/R_2 + R_3/R_2}\right)V_g\right)$$

$$+ \frac{k_2}{(1 + R_3/r_{a2})} \quad \ldots \quad \ldots \quad \text{(vii)}$$

Comparison of (i) and (vii) shows the results of Fig. 4, column 4. For complete equivalence of the circuits of Figs. 11 and 12, equations (iv) and (vii) must have identical coefficients of current, of V_a', and identical constant terms. Over and above the conditions for a.c. equivalence, the equations show that there is a further condition to be satisfied for d.c. equivalence, *viz.*:

$$\frac{k_1}{(1 + R_1/r_{a1})} = \frac{k_2}{(1 + R_3/r_{a2})} \quad \ldots \quad \ldots \quad \ldots \quad \text{(viii)}$$

But, for equal mutual conductances of the combinations,

$$\frac{g_{m1}}{(1 + R_1/r_{a1})} = \frac{g_{m2}}{(1 + R_3/r_{a2})} \quad \ldots \quad \ldots \quad \ldots \quad \text{(ix)}$$

whence, from (viii) and (ix) the additional requirement for d.c. matching is

$$\frac{k_1}{k_2} = \frac{g_{m1}}{g_{m2}} \quad .. \quad .. \quad .. \quad \text{(x)}$$

which depends on the valves alone

The condition can also be expressed in the more illuminating form

$$\frac{\mu_1}{\mu_2} = \frac{X_1}{X_2} \quad .. \quad .. \quad .. \quad \text{(xi)}$$

where X_2 is the intercept on the V_a axis of the tangent to the anode characteristic (for a given V_g) of the valve with the amplification factor μ_2, and X_1 is the corresponding intercept for the other valve.

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"Cellular" Circuits

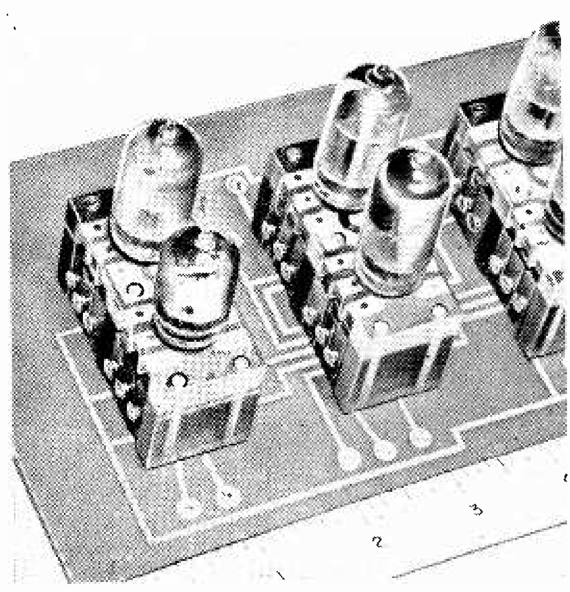
Solderless Assembly Method Using Small Replaceable Units and Printed Circuitry

By MICHAEL LORANT

PRINTED circuits, in which conducting patterns etched on plastics take the place of conventional wiring, have come into fairly wide use. For the problem of connecting components and valves to the printed sheets several solutions have been offered. However, the diversity of these solutions and their inability to gain widespread acceptance indicates that the right answer has not yet been found.

In a novel approach to the problem made by the U.S. National Bureau of Standards, small three-contact moulded blocks or cells, each containing one or two circuit elements—resistors, capacitors, inductors, are pressed against the etched circuit pattern by means of springs that are extensions of the valve socket contacts. No soldering is needed. The individual moulded cells are about ⅞in high by ½in wide by ¼in thick. Each has three contacts, one on the top and two on the bottom. The cells are grouped together in "building blocks," each comprising two valves and twelve cells held in a compact bundle by means of a suitable frame. The top surface of the block consists of a spring assembly containing the valve sockets and the necessary spring contacts. When the block is fastened to the printed base-plate by means of screws, springs in the spring assembly apply substantial pressure to the top terminal of each cell and hold the two

Part of a working circuit using the experimental cellular assembly technique. Each cell is fitted with a small knob and the blocks are spaced far enough apart to allow the cells to be withdrawn.



bottom terminals firmly in contact with the printed circuit pattern. Positive and noise-free electrical connection is further assured by the application of a thin film of grease to the cell contacts.

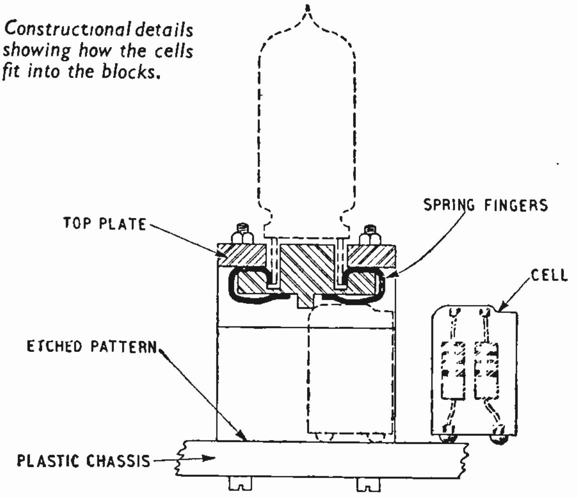
The two-valve block is considered an optimum-sized sub-assembly in the new system. Any number of the blocks can be mounted on a suitably printed base-plate of sufficient area. Potentially inexpensive, they are compact (about $2\frac{1}{4}$in × 1in × $1\frac{3}{16}$in, not including the valves) and are easy to store and to handle. They are extremely rugged, and as long as a block is secured to the base-plate none of the cells can vibrate or shake loose.

A noteworthy feature of the technique is that it enables both blocks and cells to be replaced quickly without the use of plugs or connectors. If conventional plug-in assemblies were made as small as these blocks the plugs would add substantially to both size and cost. The elimination of both soldering labour and multiple connectors results in a double saving.

In case of trouble, an entire block can be easily removed for repair or replacement, simply by loosening the screws that hold it to the base-plate. Either on the spot or after return to the factory or servicing department, defective blocks can be quickly repaired by replacing faulty cells. Each cell is identified by suitable markings.

An important aspect of the use of three-terminal cells in the new technique is the fact that positive pressure can be maintained at three points, and only three points, by a single spring. Fortunately, in the great majority of electronic circuits no more than two circuit elements need be connected electrically to a single valve electrode. A three-terminal cell, therefore, besides being easy to hold under firm spring pressure, will in general provide enough electrical contacts for the elements associated with any valve pin. Exceptional cases can be taken care of in the new system by providing for a spare cell not connected to the valve pins. It is also possible to provide for three-terminal cells of double or triple the standard thickness to accommodate occasional oversized elements.

Constructional details showing how the cells fit into the blocks.



An experimental nine-valve cellular circuit already constructed at the Bureau appears to confirm the practical possibilities of this type of construction. For convenience, the limited number of cells needed were formed at room temperature using a casting resin, although this is not the best material. For quantity production, cells could be moulded in phenolic by the process now in wide use for making resistors and capacitors. The components would be spot welded together and to the terminal tabs before moulding.

B.B.C. TELEVISION EFFECTS

SOME interesting electronic methods of combining pictures are now being used by the B.B.C. in some of their television programmes. In one, known as "inlay," the picture from one camera is replaced over a chosen fixed area by the picture from another camera—the effect being rather like an inset magazine photograph. The changing from one camera to another is done by an electronic switch. This is controlled by the output of a flying-spot scanner, synchronized with the cameras, which scans a mask cut to the required shape for the inset picture. Thus when the flying spot comes out from behind the mask, light falls on the photocell and the electronic switch selects the main camera output; when it goes back behind the mask the light is cut off and the switch selects the output of the "inset" camera.

In the other method, called "overlay," the actors are seen moving against a background which is actually being generated by another camera or a film scanner. It achieves electronically the same effect as the familiar back-projection technique, but without all the cumbersome film apparatus that is normally needed. Simple addition of the two pictures would, of course, give a "ghost" effect, so parts of the background picture have to be removed to make room for the foreground picture.

This is again done by electronic switching between the two cameras, but instead of a mask to control the switch the apparatus uses a "silhouette" signal corresponding to the outline of the foreground picture. To obtain this, the foreground subject, say an actor, is televised in front of a plain black background, and the resulting camera waveform is clipped top and bottom to produce a square pulse. When the pulse is "on" it causes the electronic switch to select the picture from the foreground camera and when it is "off" the picture from the background camera. Thus, wherever the foreground subject moves it is always fitted neatly into a suitably shaped hole in the background.

"Television Engineering"

THIS is the title of a new textbook primarily intended for the B.B.C.'s operation and maintenance staff. The first volume, with the subtitle "Principles and Practice," written by S. W. Amos, B.Sc.(Hons.), A.M.I.E.E., and D. C. Birkinshaw, M.B.E., M.A., M.I.E.E., in collaboration with J. L. Bliss, A.M.I.E.E. (all of the B.B.C.), has just been issued by our publishers for *Wireless World* by arrangement with the B.B.C.

The first volume is divided into three parts: fundamentals; camera tubes; television and electron optics. Treatment is non-mathematical, except in the appendices. The book runs to 300 pages, with 188 illustrations. Price is 30s. (postage 8d).

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Flywheel Synchronization

Some Further Notes

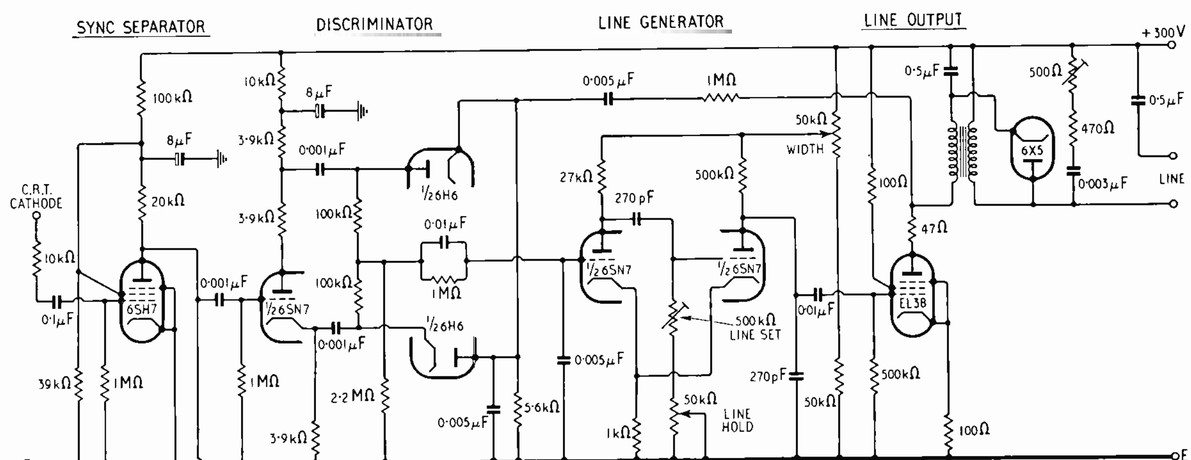
By B. T. GILLING

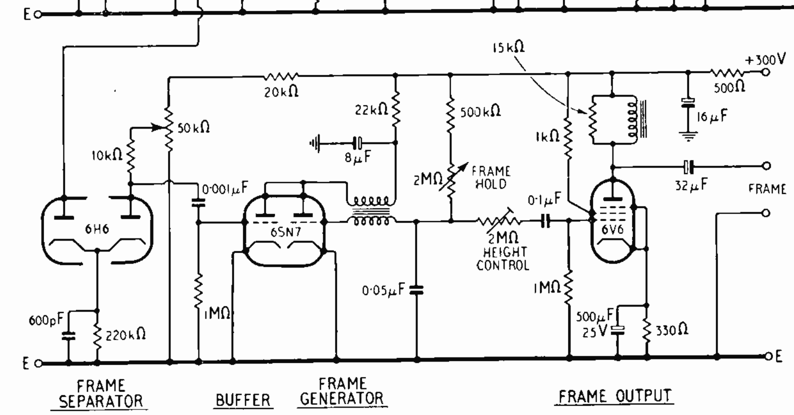
SINCE writing the original article (*Wireless World*, March 1953, p. 137) the writer has installed a multivibrator time-base in his receiver and he feels that the changes desirable when using this form of sawtooth generator are worth description. The complete circuit, from sync separator to line and frame output, used by the writer, is shown in Fig. 1. This circuit gives really steady verticals and frame interlace of a very high order. The frame separator is one of those described by G. N. Patchett (*Wireless World*, August 1952, p. 317, Fig. 19) and this article should be consulted. In the writer's set no correction for frame linearity proved necessary, but usually some is needed.

Turning to the line circuit, it will be seen when compared with the original diagram (Fig. 5, March 1953) that the d.c. amplifier is no longer used, control being taken directly from the discriminator to the first valve of the multivibrator. Also there is a 2.2-MΩ resistor connected from the junction of R_6, R_7, Fig. 5, to earth. This forms the grid return of the first controlled valve to earth and was inadvertently omitted from that diagram. The pre-set 0.5-MΩ resistor in the grid of the second valve of the multivibrator in the new circuit is there to ascertain the total value. When this is found, it can be replaced by a fixed resistor, the 50-kΩ variable resistor then becoming the only line control. In the line output a conventional boost diode is employed enabling this stage to deliver a more than adequate output to cover a 12-inch tube working at 9 kV e.h.t.

The components in the output stages are all by Haynes Radio and are as follows: Scanning coils, S.112, line output transformer, TW5/109, frame output choke, LUS8F.

Apart from the output stages the circuit can be used in conjunction with wide-angle deflection and fly-back e.h.t. Several manufacturers supply components and suggested circuits for this, but when using them very special attention must be paid to the method of obtaining the sawtooth waveform for applying to the discriminator. It can be taken from the output anode as before, but in this case the series resistor must be of as high a value as possible and especially well insulated from earth. American practice is to obtain this waveform either from a special winding on the line output transformer or from the earthy end of the line scan coil, but consideration of these methods is outside the scope of these notes.





Complete circuit of the time-bases and sync separator.

Acoustic Response Curves

Measurement Based on Subjective Equal Loudness Contours

By E. W. ROGERS,* A.M.I.E.E.

THE following notes are a by-product of the development of a pair of high-fidelity earphones which the writer undertook, partly for personal use and partly for monitoring purposes in a sound rediffusion network.

The resulting 'phones were based on metallic ribbon[1] and the opinion of a number of colleagues, based on listening tests of live and recorded material, was that the reproduction was natural, with the exception of a slight heaviness on the very low frequencies. Methods of calibrating the response were considered. As an artificial ear was not available, experiments were made to see if the Fletcher and Munson[2] calibration of the standard ear could be used.

The threshold-of-hearing response curve seemed a promising basis. Tests showed that a simple set-up of apparatus, Fig. 1, was sufficient.

A room was selected in the Redifon laboratories, the apparatus installed, and 18 people, over a period of some weeks, were persuaded to conduct the experiment and record their results. It was found early on, that to obtain repeatable results, the room noise had to be reasonably consistent, and all measurements were made during the factory normal mid-day shut down period. After some practice, nearly all the people making the tests were able to determine the level at which the sound of the input frequency became inaudible with a repeatable accuracy of ±2db over most of the range. An input level could be determined which, if increased by 2db, provided a definite sensation of sound in the ear; or, if reduced by 2db, was definitely undetectable. Slightly wobbling the frequency dial of the oscillator was a help. The measurements were tabulated from the attenuator setting required to reduce the signal to be inaudible at the prevailing room noise level, with one volt fed from the oscillator over the range 30 to 15,000c/s. The operators were particularly requested to search out peaks and dips, and to record the extremes.

The results were collected and prepared in graphical form. From the start, it was obvious that all had a general shape, roughly the inverse of the Fletcher and Munson curve, but some wider variations in detail were noted. Any curves with obvious freak dips or peaks were eliminated, and 12 of the original 18 were left which fell between two lines, deviating by about 10db. An average between these was calculated and drawn (Fig. 2).

The next step was to add the resulting curve to the threshold of hearing, to obtain calibration of the earphones. An immediate difficulty arose. The background noise was definitely not below the threshold of hearing, as was obvious when making the tests. This subject is dealt with later in more detail. The Fletcher and Munson curves (Fig. 3) show the ear to be less sensitive to changes of intensity at low frequencies than to equivalent changes at middle and high frequencies. If, then, the noise level had an actual value of 30db, in other words, an artificial threshold of hearing of 30db at 1,000c/s, and the ear response curve for 0db were used, the resultant level plotted at 50c/s would be in error by 17db.

A calibrated microphone and amplifier were coupled to a frequency-selective amplifier (harmonic analyser) and the noise level measured over a range of frequencies. This indicated a much higher back-

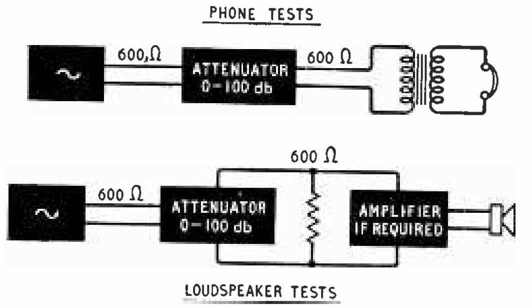


Fig. 1. The apparatus required is simple, both for testing earphones and loudspeakers.

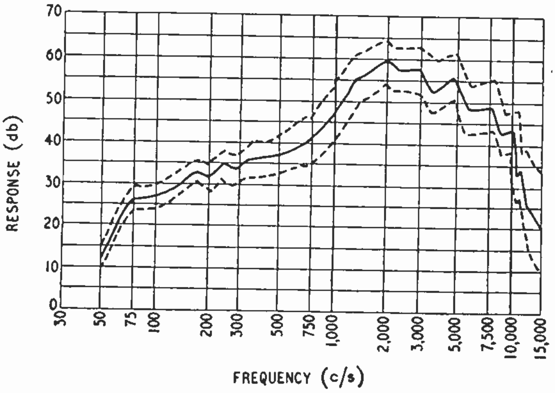


Fig. 2. Response (uncorrected) from attenuator settings for threshold level at different frequencies.

* Redifon, Ltd.
[1] British Patent Specification 604908.
[2] Fletcher and Munson, *J.A.S. Amer.*, October 1933, page 82.

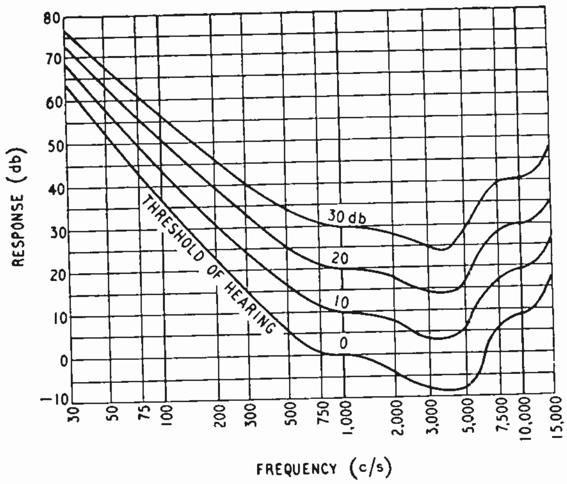


Fig. 3. Contours of equal loudness for normal ears (after Fletcher and Munson). Odb = 0.00104 dyne/cm².

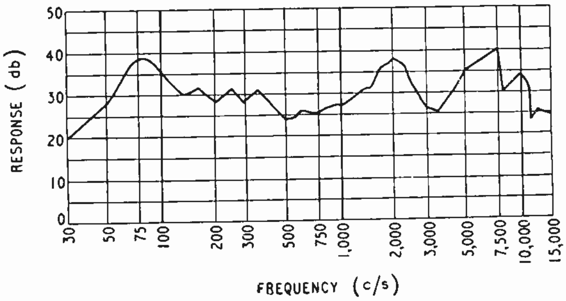


Fig. 4. Curve of Fig. 2 corrected by the 30db loudness contour, chosen as the equivalent noise threshold.

ground level than was expected, but it was found difficult to arrive at any actual figures for the results obtained, due to the rapid fluctuations which occurred at any particular frequency and to the random nature of the noise. A simple filter circuit was prepared, which gave a response, from 2,000c/s to 50c/s, roughly the inverse of the 30db ear constant-level curve, and level above those frequencies, the tests having shown that the noise components were concentrated in the lower band.

A high-gain amplifier was calibrated with the filter and the noise band measured in free air. Results showed a figure of 35 to 45db over a number of days, at mid-day. 40db was a somewhat startling figure for a room considered to be quiet. The next step was to ascertain the noise level at the ears, when covered by 'phones. This was established rather crudely by using the 'phones as a microphone in place of the calibrated microphone, and noting the difference of reading of the output when the 'phones were in free air and when worn on the head. The latter showed a reduction of 10db, approximately, giving a noise level of 30db for the tests. This curve was chosen from the equal-loudness curves, the average response added to it, and the resultant curve for the headphones was as shown in Fig. 4. The db scale has an arbitrary level.

At this stage, the 'phones were sent to the N.P.L. for calibration, the results are shown in comparison, in Fig. 5. The N.P.L. stated the curve gave results which would apply equally well to the human ear up to 3,000c/s, but above that frequency, wider deviations could occur. They were unable, at the time, to extend the measurements above 8,000c/s.

The marked difference between the level of the two curves above 5,000c/s called for a careful re-check of all the measurements and calculations already made, but without changes. As, in effect, the N.P.L. were not warranting the figures above 3,000c/s, it was felt that the Redifon response curve could be substantially correct, but remained unproved. There is no evidence of the N.P.L. apparent cut off at 7,000c/s when swinging an audio oscillator around this frequency at any input level. As the N.P.L. curve actually calibrated the output in sound pressure units, against an input level to the primary of the 600-ohm transformer, it was a simple matter to calculate back to the actual sound level called the threshold of hearing in the original tests. This showed a level of 27db above the threshold of hearing which agreed quite well with the direct noise measurements.

The writer has re-checked the response curve with earphones (or his own hearing response) half-a-dozen times since the original calibration, with results between 30 and 9,000c/s within ±2db except for narrow-width deviation of larger amplitude. Above 9kc/s, advancing years have taken their toll, and the cut off frequency had dropped from 15½ to 14½kc/s, and the level at 13kc/s has apparently dropped by 10db in 10 years. The tests have shown the importance of maintaining the same level of background noise, or alternatively, of knowing the value of this level, and using the correct curve. It has been found that a cold in the head can have a devastating effect on the high-frequency response of the ear. With heavy catarrh a 40db dip at 9,000c/s ha; been observed.

Some years later, the writer applied the same method in an attempt to calibrate loudspeakers, in various enclosures, in an ordinary lounge room in the domestic scene. The bugbear of measurements is standing waves at the lower frequencies, which make an ordinary response curve look like a distorted comb; also, the complexity of the gear required puts measurements beyond the facilities of the average radio enthusiast.

A few experiments indicated that standing waves apparently ceased to give trouble as the intensity of sound dropped towards the threshold of hearing. At 100c/s for example, measurements could be taken at 8ft from the loudspeaker in a room of floor space 25ft×12ft, and be within ±3db with the head at different angles to the axis of the speaker, and with

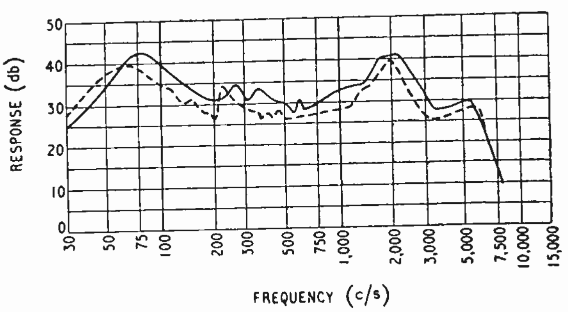


Fig. 5. Curves of two Redifon "foil" earphones, obtained by measurement of sound pressure output. 20db = 1 dyne/cm².

check measurements made over a number of days.

The possible explanation is that reflected sound, being of lower amplitude than direct sound, will reach the ear at a level below the threshold of hearing. It was found that measurements were less simple than when calibrating headphones, probably due to the attenuation of higher-frequency external noises by 'phones. Any noise of a non-steady character such as, the rustling of a newspaper, crackling of a fire, etc., had a completely demoralizing effect when exploring the lower registers. A steady noise, such as the mechanical vibration of a mains transformer, was not disturbing. It was, therefore, essential to have a room to oneself late at night, when traffic noises were at a minimum. Noise measurements in the writer's home in a rural area, showed figures varying between 25 and 30db under these conditions, and the 30db equal loudness contour was chosen.

First tests showed considerable inconsistencies in measurements above 6,000c/s which were puzzling until it was found the audio transformers in the amplifier and oscillator used, radiated energy in an erratic form at frequencies above 6,000c/s. This effect was eliminated by covering the offending apparatus with blankets. Fig 6 shows the response of two well-known loudspeakers of a 12in type, mounted in an 8 cu ft vented cabinet; Fig 7 shows the response of a small 3in loudspeaker mounted in a 1-cu ft box.

Points to be watched when making tests are:—

1. A reasonably constant noise level is essential. This means either local traffic noises must be excluded or tests to be made during the night hours.

2. It is probable that the noise level will have to be about 30db maximum to give reasonable results. Noise levels higher than 30db are unlikely to be constant enough for repeatable results to be obtained. In rural areas, noise levels of 20db or less may be obtainable. As a guide, at a room noise level of 20db, a train five miles away can be distinctly heard through an open window, and the mechanical hum noises of a radio set would probably be audible at all parts of the room. It is probably safe to take the 30db noise level characteristic for the ear, unless the operator is confident he has exceptionally quiet conditions, when the 20db curve can be used.

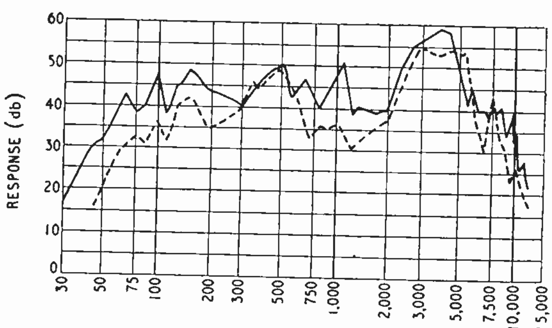


Fig. 6. Response curves of two 12in loudspeakers in 8 cu. ft vented cabinets. Microphone distant 8ft on axis.

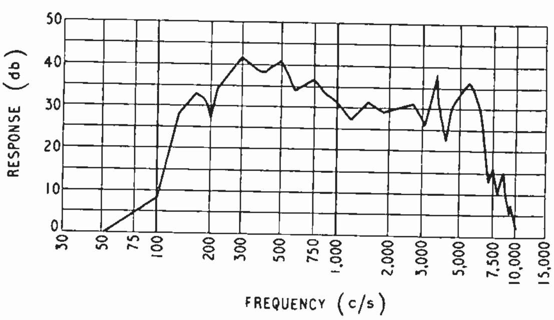


Fig. 7. Response curve of 3in loudspeaker in small vented box mounted on wall. Microphone 15 deg off axis, distant 6ft.

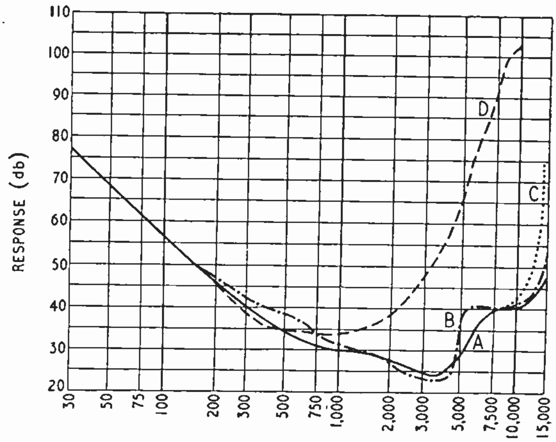


Fig. 8. Equal-loudness contour, 30db level. A, average normal ear: B, author's ears 1943; C, author's ears 1953; D, example of person with high-frequency deafness.

3. Measurements should be taken as far away from walls and large objects as possible, preferably towards the centre of the room.

These precautions taken, it should be possible to compare differences between various loudspeakers and enclosure cabinets, etc., by assuming the average ear characteristics apply to the operator. Should means be available for checking these characteristics, then naturally the modified curve would be used. Great differences from the average can occur, as shown in Fig. 8.

Another method of approximating characteristics of the operator's ears is to repeat the experiment of a number of people (preferably under 30 years of age), measuring the response of a particular system and averaging the result, as described earlier.

If the particular characteristic of the ear can be estimated by one or other of these means, then it is the opinion of the writer that the overall performance of audio systems, under normal room conditions, can be ascertained with an accuracy at least equal to some other more complicated methods, between the frequencies of 30 and 11,000c/s. Much more investigation is required to confirm or disprove this opinion.

Probably, the easiest method of making measurements is to feed the variable-frequency oscillator via a calibrated attenuator into the pickup input terminals of the receiver or amplifier, the overall response of which can be determined in the usual way. It is obviously desirable that the hum level of the system should be lower than the prevailing noise level of the room at the distance at which the measurements are made from the loudspeaker.

In conclusion, the writer would point out that the opinions expressed are his own, and do not necessarily represent the views of Redifon, Ltd.

Voltmeter Loading Again

Measuring True Voltage With Only One Meter

By R. A. WIERSMA*

IN the June issue the potentiometer method of measuring the true voltage in a high resistance circuit was described. This is, of course, the best method of measuring true voltage and can be recommended when measurements in high resistance circuits are carried out frequently. If possible the potentiometer should be fitted up in a permanent form, and perhaps combined with a diode to make it usable also as a peak reading a.c. voltmeter which will be accurate up to at least 50 Mc/s.

However, most people do not have sufficient use for such a device to justify making it up in a permanent form. When servicing or checking electronic apparatus, a large number of voltage checks may be made rapidly at various points in the circuit. Generally, the universal meter has sufficiently low consumption to measure all the voltages with the required accuracy. In cases of moderately high circuit resistance a higher voltage range on the meter is used. The lower consumption of the meter produces less disturbance of the voltage, but there is the disadvantage of having to read a small deflection. Occasionally the loading is too great even on, say, the 1,000-V range, or the deflection is too small to be useful, but it would take too long to find and connect up the necessary galvanometer and components for the potentiometer method. Nevertheless it is possible in many cases to deduce quickly the true voltage by using the universal meter only, in the following way.

Suppose we have two resistors R_1, R_2, connected in series across a supply of V volts, as shown in Fig. 1,

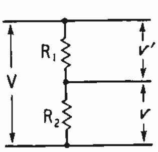


Fig.1

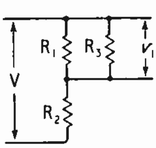


Fig.2

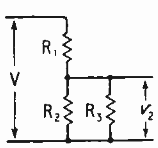


Fig.3

and we wish to measure the voltage across R_2. The true voltage is $v = V \times \dfrac{R_2}{R_1 + R_2}$.

The true voltage across R_1 is $v' = \dfrac{R_1}{R_1 + R_2}$.

$$\text{Thus } \frac{v'}{v} = \frac{R_1}{R_2}.$$

Connect the voltmeter across R_1 as shown in Fig. 2. Let the meter resistance be R_3 on the range used.

The resistance of R_1 and R_3 in parallel is $\dfrac{R_1R_3}{R_1 + R_3}$.

Thus the voltage across R_1 and R_3 in parallel, which is the voltage indicated on the meter, is

$$v_1 = V \times \frac{\dfrac{R_1R_3}{R_1 + R_3}}{\dfrac{R_1R_3}{R_1 + R_3} + R_2} = V \times \frac{R_1R_3}{R_1R_3 + R_1R_2 + R_2R_3}$$

Now connect the voltmeter across R_2, as shown in Fig. 3, *using the same voltage range*, so that the resistance of the meter is again R_3.

The voltage indicated on the meter is

$$v_2 = V \times \frac{\dfrac{R_2R_3}{R_2 + R_3}}{\dfrac{R_2R_3}{R_2 + R_3} + R_1} = V \times \frac{R_2R_3}{R_2R_3 + R_1R_2 + R_1R_3}$$

Examination of the expressions for v_1 and v_2 shows that the denominators are equal. Therefore $\dfrac{v_1}{v_2} = \dfrac{R_1}{R_2}$ which is equal to $\dfrac{v'}{v}$.

That is, the ratio of the measured voltages is the same as the ratio of the true voltages, which exist when the meter is removed. From this we can obtain v as follows.

$$\frac{R_1}{R_2} + 1 = \frac{v_1}{v_2} + 1, \text{ or } \frac{R_1 + R_2}{R_2} = \frac{v_1 + v_2}{v_2}$$

$$\text{Hence } \frac{R_2}{R_1 + R_2} = \frac{v_2}{v_1 + v_2}$$

$$\text{and } v = V \times \frac{R_2}{R_1 + R_2} = V \times \frac{v_2}{v_1 + v_2}$$

So we must measure also the supply voltage V. This can be done on any suitable range of the meter. Actually, there is no need to memorize any formulæ, as the following simple example shows.

Reading across h.t. supply : 500V *on* 1,000-V *range.*
Reading across upper resistor : 300V *on* 400-V *range.*
Reading across lower resistor : 100V *on* 400-V *range.*

So the measured voltage across the upper resistor is three times the measured voltage across the lower resistor.

From the above theorem we deduce that, when the meter is disconnected, the voltage across the upper resistor will still be three times the voltage across the lower resistor, or the voltage across the lower resistor is ¼ of the supply voltage, or 125 volts.

There are two limitations to the application of this

* Wayne Kerr Laboratories.

method which must be borne in mind. First, the supply voltage V must be derived from a source of sufficiently low internal impedance, so that the connection of the meter in any of the three positions does not appreciably change the value of V. This can be assumed to be true when the total current drawn from the supply greatly exceeds the current drawn by the meter during the measurements.

Secondly, the analysis assumes a linear network, that is, one in which all the elements obey Ohm's law. This makes the method useless in certain valve circuits. For example, if R_1 is the anode load of a pentode, the d.c. anode resistance being represented by R_2, then since the anode current is almost independent of anode voltage, R_2 in this case is extremely non-ohmic, and the method cannot be used. However, in the case of the screen grid of a pentode with a high resistance dropper, the voltage/current relation for the screen grid is roughly ohmic and the method should give a fair approximation to the true voltage.

The method is actually a simple application of Thévenin's theorem. Thus it is applicable to more elaborate networks than that described and can also be used on a.c.

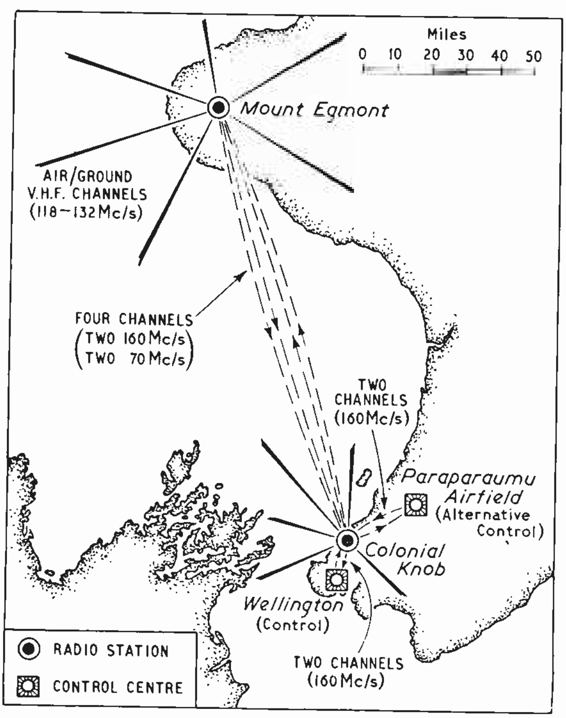
Multi-Station Air-to-Ground Communications

New Zealand V.H.F. Area Coverage Scheme Using Radio Links Throughout

THE first stage of an extensive v.h.f. ground-to-air area coverage communications scheme will shortly be coming into full operation in New Zealand. Planned by the Civil Air Department it is operated entirely over radio channels with the control centred at Wellington and with transmitting and receiving stations at Colonial Knob, nine miles away, and at Mount Egmont, a further 132 miles distant.

An alternative control centre is to be set up at Paraparaumu airfield about 20 miles from Colonial Knob so that the final scheme will involve three two-way radio links, e.g., Wellington-Colonial Knob (9 miles), Colonial Knob-Paraparaumu (20 miles) and Colonial Knob-Mount Egmont (132 miles). The main radio centre of the system is thus at Colonial Knob.

Outline map showing the locations of the transmitting-receiving stations and the control centres



Each outgoing radio link carries six speech channels for modulating six v.h.f. ground-to-air transmitters, an engineers' speech channel and various audio tones for switching, monitoring and general control of the distant unattended stations. As the ground-to-air communication system is a simplex one requiring separate transmitting and receiving frequencies all radio-links are duplicated for the outgoing and incoming traffic and control channels. The tone circuits of the incoming links are used for remotely controlling and monitoring the receivers.

Each inter-station radio link is frequency modulated by a band of frequencies extending from 300 c/s to 30,000 c/s allocated as follows:—

300 to 3,000 c/s—engineer's speech circuit.

3,000 to 6,000 c/s—switching and supervisory tones.

6,000 to 30,000 c/s—six amplitude-modulated sub-carriers for ground-to-air (and vice-versa) traffic. The suppressed-carrier single-sideband system is employed.

Since the lower sidebands only of each sub-carrier channel are used and mixed for transmission, speech is effectively scrambled and the secrecy of the system is therefore excellent.

For the inter-station radio links v.h.f. multiplex equipment designed jointly by Pye and Ericsson Telephones is employed.

Colonial Knob and Mount Egmont are at a good altitude (3,500ft and 1,500ft respectively) and so, despite the 132 miles separating these stations, the path is true line-of-sight. Transmitters of about 50 watts output and Yagi aerials having 10-db gain are expected to provide adequate and reliable signals in both directions without the help of intermediate relays.

Two radio channels in the 70-Mc/s and two in the 160-Mc/s bands are allotted for the main and stand-by equipments for this path and by operating in both bands simultaneously it is expected that some useful data will be accumulated in time on v.h.f. propogation over long distances. Ultimately the band giving the more consistent signals will be adopted permanently for the main service. As the remaining two links are comparatively short ones 10-watt transmitters operating in the 160-Mc/s band will be employed.

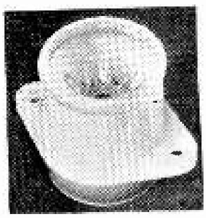
The six ground-to-air radio channels will be in the normal aircraft communications band of 118 to 132 Mc/s and will be amplitude modulated.

Manufacturers' Products

NEW EQUIPMENT AND ACCESSORIES FOR RADIO AND ELECTRONICS

E.H.T. Valveholder

A MINIATURE nine-pin (Noval) valveholder designed for use in television e.h.t. rectifier circuits where high voltages are encountered has been introduced by the McMurdo Instrument Co. Ltd., Victoria Works, Ashtead, Surrey. It is described as the Type XM9/UV and consists of a nylon-loaded Bakelite socket moulded into a polystyrene sleeve designed to fit a chassis hole of the size used for a normal octal valveholder.



McMurdo 25-kV e.h.t. Noval valve-holder.

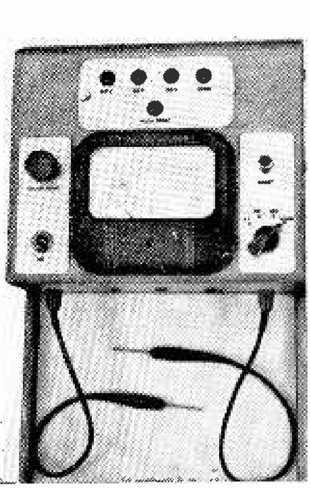
It is claimed that this valveholder will operate safely with a voltage difference of 25 kV between the holder contacts and chassis and it obviates the need for stand-off insulating pillars sometimes used for mounting e.h.t. rectifier valves.

Battery Tester

A TEST set intended primarily for use in radio and electrical retail establishments handling h.t. and l.t. batteries, and which cannot be damaged by an overload however severe, has been introduced by Clive Courtenay and Company, 5, Horsham Road, Dorking, Surrey, and the price is £16 16s 0d.

Known as "Test Set Type A" it is a.c.-operated and provides three ranges for voltage measurements and one for resistance, the full-scale readings in each case being 2.5 V, 25 V, 150 V and 100,000Ω respectively. The voltmeter resistance is 200 ohms/volts. The basis of the instrument is a $4\frac{1}{2}$-in rectangular-faced moving-coil meter and this is flanked by a range-selection switch and an ohms adjuster, while above is a line of indicator lamps showing the range in use.

Courtenay overload-protected counter voltmeter and test set.

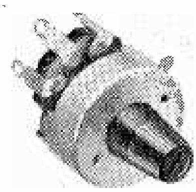


Electrical cut-outs disconnect the meter from the test circuit whenever a 50% overload occurs on any range and these operate about 10 times faster than the meter movement.

Television Volume Control

A PRE-SET adaptation of the Model A carbon-track potentiometer produced by Morganite Resistors for use in television receivers is now available. As the illustration shows, the Type AP is fitted with a moulded "sugarloaf"-shaped insulated sleeve over the spindle and this is designed for either finger or screwdriver adjustment. The volume control measures $1\frac{1}{8}$ in diameter and is secured by two 6-BA screws.

Morganite Type AP pre-set volume control for television receivers.



General production is scheduled to commence on November 1st of all the popular resistance values. The makers are Morganite Resistors, Ltd., Bede Trading Estate, Jarrow, Co. Durham.

Interference Suppressed Flashers

IN order to mitigate the nuisance of radio interference from flashing signs, the General Electric Company, Magnet House, Kingsway, London, W.C.2, in collaboration with the Post Office engineering department, has produced a lampholder adaptor flasher with a built-in suppressor. This has passed the relevant clause for interference suppression in BS800 covering the television bands of 40 to 70 Mc/s. It is also quite effective on the sound broadcast bands.

The price of this radio interference suppressed flasher is 14s and it is available for voltages of 100 to 260 and from 15 to 100 watts rating. A special version of the unit for use with Christmas and party decoration lamps is being developed.

RANDOM RADIATIONS

By "DIALLIST"

Business as Usual

WHEN THE DAVENTRY third programme station had to make a big reduction in its output power owing to aerial trouble I quite expected that reception in my home would become poor. It seemed more than likely that the lowered output would automatically put me well into the fringe area and that fading would become a nuisance. Nothing of the kind happened: the signal came in almost as strongly and quite as steadily as ever. Many people must have had much the same kind of experience, for I gather from a friend in the B.B.C.'s Engineering Department that there were surprisingly few complaints. A pretty good show, I feel, that the station's coverage should have been so well maintained while major repairs were in progress.

Defining Electronics

ELECTRONICS HAS BECOME so enormous a subject that I doubt very much whether even *Wireless World* readers (who seem able to find most of the answers) will succeed in hitting on any concise definition which really covers it properly. R. A. Fairthorne's "study and application of sub-molecular phenomena as elements of control" in the September issue is surely over-wide; would it not include nucleonics and apparatus such as the synchro-cyclotron and the atomic pile? The same criticism applies to Henry Morgan's "anything electrical which I do not understand:" how many radio or radar specialists, for example, would score good marks in an examination on the long-distance distribution of high power by grid systems? The best definition that I can think of is simply: Electronics is the branch of electricity mainly concerned with microamperes, microvolts and microseconds. Or, more briefly still, the "micro" branch of electricity.

The Pity On't

ISN'T IT a queer and tragic thing that no sooner does science develop some new thing as a benefit for humanity than someone ups and says "by Jove, I can see a way of using that for killing people?" The inventor of gunpowder thought of it only as a means of producing firework displays; but his fellows were quick to see how shortsighted this view was. It has been the same old story with the internal combustion engine, the aeroplane, the telephone and radio. Now it's to be the turn of that eminently peaceful development, television. It has been found, I read recently, that an airborne TV camera with a radio link can be used to direct artillery fire; the battery commander just watches a television screen, observes the bursts of his shells and orders appropriate corrections to the gunner. Simple; isn't it?

Animal Radar

IT WAS ESTABLISHED some time ago that bats avoid obstacles by means of a kind of radar which uses sound pulses and sound waves. As he flies, the bat continually emits short, high-pitched squeaks. His eyesight is very poor but the returning echoes of his squeak pulses give him warning of anything in his way. How effective the system is was borne in on me when a bat came in through the open window as I sat writing these notes. Until I was able to shoo him out he flew at full speed all the time, banking and swerving within an inch or two of walls, wires and so on, and never hitting anything. Birds which fly in flocks may execute those marvellous simultaneous turns with never a collision by using similar methods. Skeins of ducks and geese, for instance, keep up a continual clatter and most people must have heard the voices of a covey of partridges in flight. It has now been found that some fish which swim in dense shoals, especially those of the dim or dark deep waters, are not as dumb as they were thought to be. They, too, make high-pitched squeaking noises and it seems possible that they have their own type of marine radar.

Dipoles and A.M.

A WHILE AGO, I mentioned that I could obtain excellent reception of the Wrotham f.m. transmissions with the simplest of indoor dipoles at a range of 50 miles, but that results on a.m. were not quite so good. One or two readers ask what I'm driving at: do I mean that dipoles aren't suitable for a.m. reception? Far from it; they're the right thing to use for any sort of modulation on the metre waves. The point is that with f.m. you get everything that's there, so long as your aerial brings in a signal of sufficient amplitude to work the limiter. My flex dipole on the picture rail of a ground floor room does this for f.m.; hence reception is fine. The amplitude of the f.m. signal does not vary, but remains constant. That of an a.m. signal is, by definition, continually varying, and on the indoor dipole parts of it fall below the minimum level required for proper reception. One of the big advantages of f.m. over a.m. is that a simple and inexpensive aerial suffices at considerably greater ranges.

Soot and Whitewash

"FREE GRID" AND I have more than once had something to say about the average woman's inability to tune a broadcast receiver to anything like resonance. How often does one find a musical member of the fairer sex listening enraptured to a transmission from the Festival Hall and blissfully unconscious of horrid distortion due to mistuning? Still more surprising is their treatment of the contrast control of a television set. They turn it up and up until the screen image has the "soot-and-whitewash" appearance of a badly over-exposed photograph. Having diffidently offered to improve the picture, you show one such offender how to adjust for the maximum amount of detail. Her gratitude is mingled with flattering remarks about your cleverness. Thanks to you, she now knows *exactly* what to do. She may know what to do; but does she do it? Call a few days later and you are more likely than not to find her gazing contentedly at images sootier and more whitewashed, if possible, than those which you saw at first.

All Sorts to Make a World!

Dear Sir,

In reference to your article in the July *Wireless World*, what earthly right have you to place upon the motorist the onus of spending money to improve your television entertainment? This interference is not due to any development in car engine design. This radiation, always present, is only apparent now as a nuisance because of the development of this "so-called" entertainment.

If 2,250,000 TV users want car owners to fit suppressors, let them provide the "couple of shillings" per car: we motorists will contribute the ten minutes to have them fitted.

Is it your theory that as the motorists already contribute so much to the national Exchequer, another couple of shillings will do them no harm? Or, perhaps, Mr. Diallist, you have shares in a company making the suppressors which your proposed legislation will make compulsory?

Yours truly, ———.

UNBIASED

By FREE GRID

The Mantle of Lord Roberts

DESPITE ALL THE TALK there has been of drastic measures to reduce the interference with sound broadcasting and television caused by the use of "unsilenced" electrical apparatus, the trouble is as bad as ever. Something will have to be done soon, however, not so much for the sake of allowing listeners and lookers to have interference-free enjoyment of broadcasting as in the national interest.

Now that information has been published about our guided missiles and the way in which they "home" on the quarry which they are chasing, I can refer freely to a grave menace to our national security which unsuppressed electrical interference is likely to cause in any future war.

It is quite simply explained. As most of you know it is possible for the radio operator of a plane to know when his craft is passing over or even near a large town, no matter how thick the fog or how well the town is blacked out, for he flies into a veritable cloud of electrical interference coming up from below. This elementary fact is no secret and I first referred to it in these columns many years ago.

The interference comes not only from the usual sources of which we think when it bedevils our enjoyment of broadcasting but also from the innumerable electric lighting switches which at any given moment are being operated in a large town. Now this is as well known to our potential enemies in Ruritania as it is to us, and after the marvellous accounts given recently of the deadly effect of our guided missiles on any marauding planes, the Ruritanians will waste no more money on constructing such out-of-date devices. Instead they will put all their resources into making guided rockets which will be steered in the general direction of our large towns and then left to "home" accurately on to the great clouds of electrical interference coming up from below.

"But," protest the Simple Simons in our midst, "could not we do the same to Strelsau and the other large cities of Ruritania?" Certainly we could, if the Ruritanians were such fools as to neglect to suppress every switch and every electric-bell make-and-break under their control. We ought to do likewise before it is too late and it should be made a treasonable offence, equivalent to conveying information to the enemy, to omit to fit efficient suppressors to everything, including the thermostats in our electrically-heated bedsocks.

Elec-Tick Clocks

MANY OF THE THINGS which people of to-day take for granted in the realm of radio and electronics were

A treasonable offence

originally suggested in the pages of this journal. The most notable instance of this sort of thing was s.w. broadcasting to the Empire, the idea of which was first put forward by the Editor of this journal. There are several minor instances of it, however, and one is recalled to my mind by the marketing, by a well-known firm, of a series of a.c. mains clocks which are provided with a homely synthetic tick.

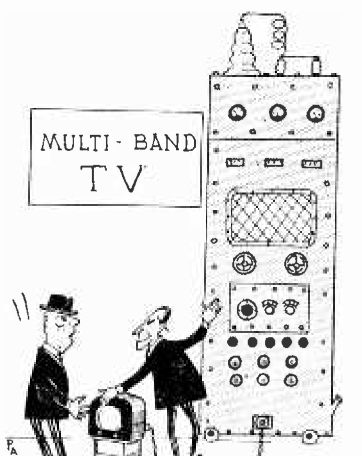
I suggested this over twenty years ago when synchronous clocks were still something of a novelty. The reason was that I never could stand the creepy-crawly silence of mains-driven clocks and said so at the time. Now at last after all these years a manufacturer has satisfied my wants and, indeed, has gone one better than my suggestion, inasmuch as a knob is provided for cutting out the tick when you've had enough of it. The manufacturer has not, however, named his product an elec-tick clock as I did; doubtless he had more sense.

History Repeating Itself

VERY OFTEN when some new industry arises, it appears at first to threaten an existing one, whereas in practice it has the very reverse effect and, in fact, gives it an unexpected boost. When broadcasting began it seemed to spell ruin to those who depended for their living on making and selling gramophone records. But, as we all know, broadcasting not only created an unprecedented demand for records but improved the quality of them because the intensive research work on the valve and its associated circuits which it instigated led to electrical recording. The development of the gramophone pick-up in the middle twenties led to the radiogram and the result of all this was that records were put on the map to an extent they had never been before.

Now history is repeating itself. Just as the vendors of gramophones and records wrongly saw in sound broadcasting the "writing on the wall," now we find the makers of home ciné apparatus in the U.S.A. fearing that TV may put them out of business. It seems to me, however, that if the right steps are taken—and taken quickly—TV will boost rather than banish home movies. All that is wanted is the production of a television set with "pick-up terminals." or, in other words, provision for scanning home-made films and showing them on the c.r. screen.

The old-fashioned projector, which has to be dug out of its box and erected together with its screen every time a film is shown, can then be consigned to the junk heap and home-ciné dealers can sell these special TV sets instead of projectors. In principle there are no technical objections to such an arrangement and in practice there are no insurmountable ones. Once marketed, not only will a boost be given to home-taken films of the family but also to the sale of commercially produced sub-standard films of events like the Coronation and of complete plays, etc., for viewing when the television programmes fail to please.



No Sir! *This* is the set and *that* is the converter