Wireless World

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Keeping Up with the Comet

SOME months ago we claimed that radio was meeting the challenge of increasing aircraft speeds fairly satisfactorily, and that any weaknesses that might exist were brought about by organizational rather than technical shortcomings. Since then, critics have convinced us that we erred on the side of undue optimism. True, the troubles are agreed to be mainly organizational, but there is still room for technical development, and in any case we must bear some responsibility for the way our techniques are applied. We must now admit that the tempo of electrical communications and, perhaps to a lesser extent, the speed of operation and range of radio aids to navigation, have failed to keep pace with the needs of 500-m.p.h. aircraft. That can and must be remedied; after all, practical radio started before practical flying, and we still have a fundamental natural advantage in the matter of speed; radio "crashed through the sound barrier" from its inception!

Judging by an anonymous article in the normally ultra-cautious journal of the International Telecommunications Union (I.T.U.), Geneva, an unseemly wrangle is brewing between the I.T.U. and the International Civil Aviation Organization (I.C.A.O.) which clearly finds existing world communication networks inadequate for the needs of modern flying. The dispute seems at present to be on mainly legalistic questions. Should certain kinds of airline operational messages be handled by the airlines' radio or line circuits (owned or leased) or should they be passed over the systems of the national administrations comprising the I.T.U. membership? But the article also discloses that some communication administrations regard civil aviation as a competitor. The speed of transit of air mail letters is now approaching that of telegrams. Implicit in such an idea is the (unspoken) conclusion that it would be no bad thing to impose a little artificial drag or handicap on the aircraft in the form of still slower operational communications.

Such thoughts are abhorrent to *Wireless World* and we believe to most radio and communication people generally. The airline operators are our customers; they are always right, and now they are in a hurry as well. We do not agree, however, with the proposals that they should have their own world-wide networks for operational communications. That would be extremely wasteful of precious radio channels which would seldom be loaded to capacity. The economic and rational solution seems to lie in attuning the tempo of the public world communication system to the speed of jet aircraft. Of what value is it for air passengers and freight to be carried at high speed if we on the ground are not ready for them at the other end?

Reflections on the Show

BY all relevant criteria, the 19th National Radio Exhibition was a great success. Public attendance was significantly higher than last year, and the show certainly served as an attractive shop-window for British productions in the way of domestic sound and vision broadcast receivers. It would be churlish to complain that some branches of radio were not fully represented; indeed, it would probably be unreasonable to do so, as the art has now strayed into far more fields than could be covered by any single exhibition. The show at least succeeded in demonstrating to the lay visitor that there is more in radio than broadcasting.

Some of this year's innovations deserve serious consideration for the future. The technical training exhibit was, we imagine, much appreciated by younger visitors considering making their careers in radio, and might profitably be extended. We should like to see B.B.C. participation in this section, as the Corporation employs some novel and apparently highly effective instructional methods at its engineering training establishment at Wood Norton.

Television demonstrations have been well conducted for some years, and the potential viewer must have been well satisfied with the arrangements made at the present show for him to study the performance of various sets. Demonstrations of high-quality sound reproduction have generally been far less satisfactory, but this year the few efforts made to improve matters in this direction were very well received. In fact, the G.E.C demonstration of stereophonic sound was widely acclaimed as one of the highlights of the exhibition.

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Radio Exhibition Review

Trends in Television and Sound 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 19th National Radio Exhibition. A description follows of aviation radio equipment as shown at the Farnborough Exhibition

TELEVISION RECEIVERS

THE straight t.r.f. television receiver, at one time the usual thing in this country, has almost disappeared, and nearly all makers now prefer the superheterodyne. This has come about through the increase in the number of television transmitters, for the superheterodyne lends itself to station selection much better than the t.r.f. set. Alterations to three or four circuits only are needed to change from one television channel to another.

This trend away from the straight set was obvious last year and has continued since then. In doing so, television has only followed in the footsteps of the sound-broadcast receiver, where for many years the straight set has been virtually dead. The fact that most television sets are now superheterodynes does not mean that they are all alike, however. In the detail of their circuitry, and often in its general form, they differ surprisingly.

Nearly every set has one stage of amplification at signal frequency. A few sets—notably those of Murphy Radio—have two such stages, but not one set without an s.f. amplifier was noted. Signal-frequency amplification is, of course, necessary to obtain a good signal-to-noise ratio; and the stage is also very desirable in order to minimize oscillator radiation. Almost invariably an r.f. pentode is used with single-tuned couplings, but some sets have a coupled pair between the s.f. valve and the mixer.

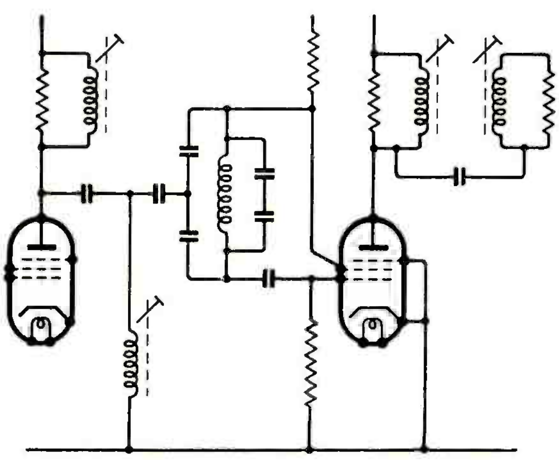

Fig. 1. Frequency-changer circuit of Ekco TC 185 television receiver.

The frequency-changer shows more variation. On the whole two-valve (or double-valve) types seem commoner than the single-valve, but the latter are well represented. Bush, for instance, still use the single-valve type with an r.f. pentode having the oscillator tuned circuit connected between the control and screen grids. The signal input is fed to a tapping at the null point on the oscillator coil. This form of circuit is also used in the Ekco receivers, as shown in Fig. 1. The oscillator is of the Colpitt's form with a capacitive tap at the null point. This is one set in which a coupled pair of s.f. circuits is used, the coupling being of the top-end capacitance type.

Pye adhere to the two-valve type of circuit, using a triode-pentode, in which the pentode acts as a mixer and the triode as an oscillator, control-grid injection being used. Quite a few sets, however, have a double-triode; notably, English Electric, Dynatron and Baird. Grid injection is usually employed, the two grids being joined through a small capacitance.

In so far as there can be said to be any general practice at intermediate frequency, it is to use two or three stages in the vision channel and two in the sound. On the sound side coupled pairs of tuned circuits are used for the intervalve couplings. On the vision side a similar arrangement is quite often used, but supplemented by sound-channel rejector circuits. However, stagger-tuned single-circuit couplings are quite common.

Pye adhere to the arrangement which they introduced last year of using four coupled circuits in cascade for each intervalve coupling. With three vision i.f. stages, there are sixteen tuned circuits in the four couplings and the selectivity is high enough to enable sound-channel rejectors to be dispensed with. This set, the FV2C, is also unusual in having three stages in the sound channel.

The cathode-trap form of sound rejector is much less often used than at one time and most rejectors are now simple wavetraps coupled in various ways to the main circuits of the intervalve couplings. The sound channel pick-out circuit can, and usually does, act as a rejector in the main video channel, but most sets have one or two rejectors in addition.

In the different designs the separation of the vision and sound signals takes place at various places. Sometimes it is immediately after the frequency-changer, sometimes one i.f. stage is common to both channels.

Reverting to the signal side, the methods adopted for station selection still vary considerably and are, in fact, much the same as last year. Bush still retain continuous tuning and Pye still use an arrangement

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of tapped coils. Some other makers prefer a replaceable sub-chassis or plug-in coils, and there is still no uniformity of method, but there is a somewhat slow trend towards arrangements in which provision for every channel is built into the set. The dealer, and in some cases the user, can then adjust the set to the required channel without having to replace any parts.

All this variety of tuning methods suggests that the perfect arrangement has yet to be found, but on the video-frequency side of the sets there is much more uniformity. A diode detector is invariably used and is directly coupled to a pentode v.f. stage. This is usually directly coupled to the cathode of the c.r. tube but not invariably so. English Electric, for instance, feed the signal to the grid and have a clamp circuit to establish the black level.

The use of inductance to maintain the high-frequency response of the video stage is less universal than it used to be. It is now nearly always supplemented by a small capacitance across the cathode-bias resistor which gives compensation by reducing feedback at the higher frequencies. In some sets this is the only form of compensation used, but in many it is supplementary to inductance loading. In some it is a trimmer and is adjusted for optimum results in the factory.

Most sets have a simple shunt diode noise limiter, which is sometimes a germanium crystal, with a bias control to set the limiting level. Some makers fit it to the video stage input, others to its output. On the sound side a series diode limiter is commonly used and requires no adjustment.

The modern tendency is all towards large cathode-ray tubes with large deflection angles—nominally 70°. The large screen area demands high-voltage operation if an adequately bright picture is to be obtained and this, together with the large deflection angle, puts heavy power demands on the scanning circuits of the receiver.

For the line scan, last year's trend towards high-efficiency circuits with h.t. boost has now become almost universal practice. The basis of the circuit is now nearly always a heavy-duty pentode feeding

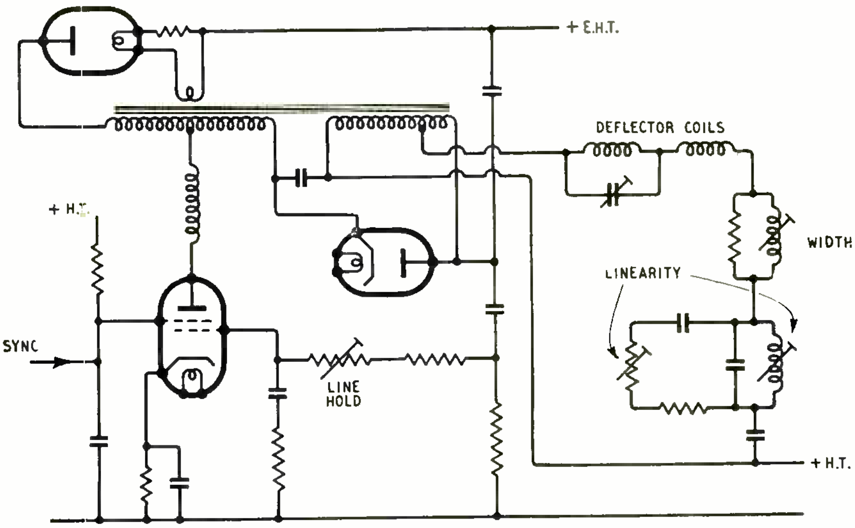

Fig. 2. Line-scan circuit of Baird P.1815 receiver.

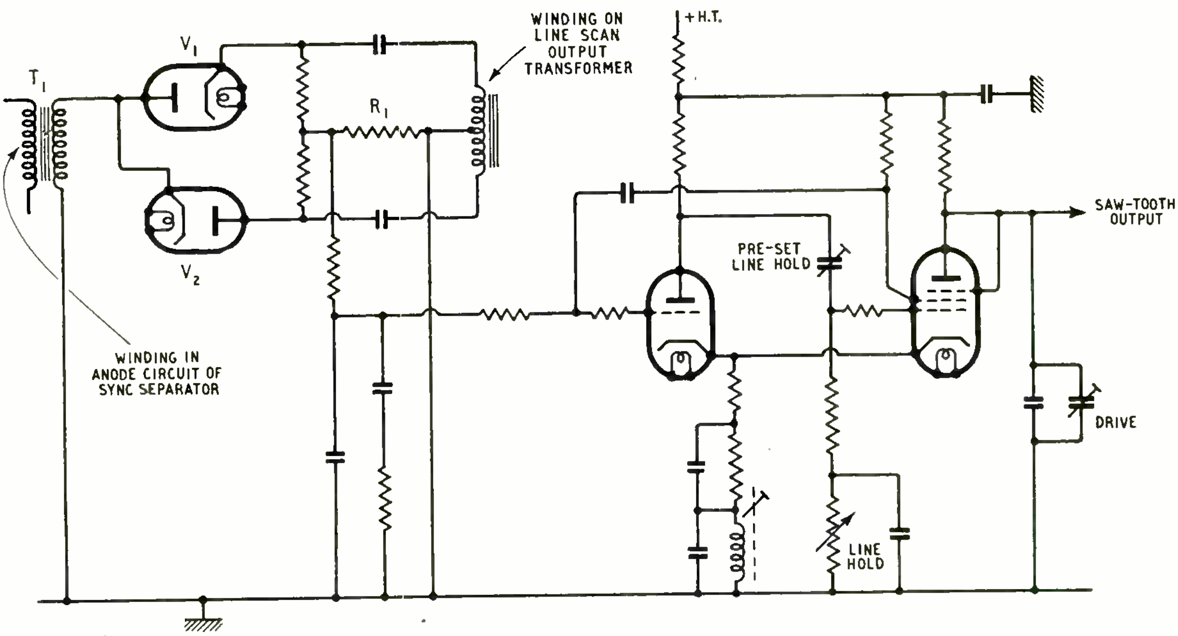

Fig. 3. Fly-wheel sync circuit and saw-tooth generator of Pye FV2C.

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the deflector coils through an auto-transformer to which an efficiency diode is connected. The e.h.t. supply is derived from a valve rectifier fed from an an overwinding on the scan transformer and up to 14 kV is obtained. Sets with tubes above 12 inches usually have 12-14 kV, whereas those with the 12-in type operate at around 10 kV.

The details of the circuits vary somewhat and, in particular, the arrangement for obtaining linearity of scan. The driving methods vary considerably, however. Self-oscillators are used quite often. Here a favourite arrangement is to utilize the control and screen grids for the regenerative action, but Ferranti employ the control grid and anode, the grid being joined to a winding on the output transformer. Baird also adopt this type of circuit and Fig. 2 shows the arrangement in their P1815 receiver. The synchronizing pulses are fed to the screen grid.

One noticeable change is a big reduction in the number of sets using a blocking-oscillator as a saw-tooth voltage generator for the line scan. Instead, there is a tendency to use a pair of valves in a multi-vibrator circuit. One example of this is in the Pye FV2C and is shown in Fig. 3. Here V_2 and V_3 (a triode-pentode) form a multivibrator; the grids and anodes (screen-grid in the case of the pentode) are cross-connected by RC couplings and in addition there is a cathode coupling which includes a resonant circuit tuned to 8 kc/s. This is for the purpose of stabilizing the frequency of the circuit.

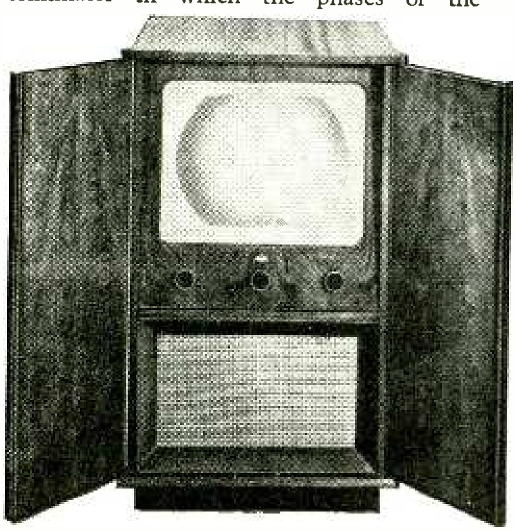
This receiver is unusual in having a form of fly-wheel synchronizing. Such circuits are standard practice in the U.S.A., where conditions are different. In this country direct pulse locking has been almost universal up to now. English Electric have used, and still use, a fly-wheel system, but only in the form of a plug-in unit for fringe areas.

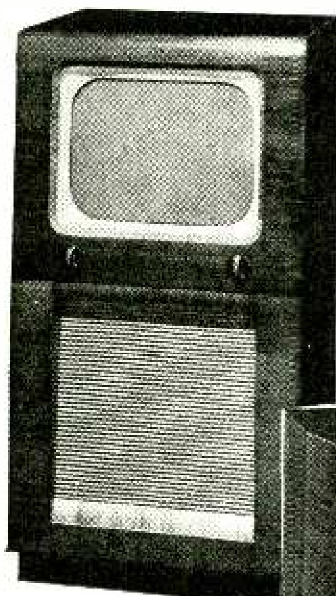
In the Pye set fly-wheel sync is always in use. Referring to Fig. 3, the pulse waveform developed in the line-scan transformer is applied to a pair of series-connected diodes V_1 and V_2 so that they conduct during the fly-back. The sync pulses are applied to the same diodes effectively in opposite phase since, viewed from T_1, the diodes are the opposite way round. The circuit is a discriminator in which the phases of the sync pulses and the time-base pulses are compared and in which a steady voltage of magnitude and polarity depending on the phase difference is developed across R_1. This is applied through an RC circuit of long time constant to the grid of V_3, where it controls the multivibrator. The synchronizing thus depends on the average effect of a large number of sync pulses rather than upon any individual one, with the result that it is relatively immune to the effects of interference.

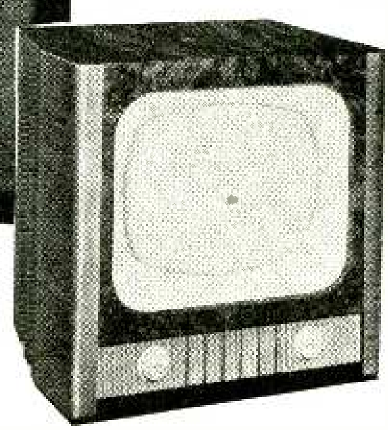
Ferguson also use fly-wheel sync, but of a somewhat different form. The saw-tooth is developed by a form of LC oscillator which is controlled by a reactance valve. The control voltage for this is produced by a duo-diode discriminator in which the sync pulses are compared with the time-base voltage.

For the frame scan two valves are usually employed and the deflector coils are nearly always fed through a transformer or auto-transformer. The latter is becoming increasingly common. There is, however, very little uniformity in frame time-base circuits; some sets use pentode output valves, others have a triode; some use the Blumlein linearity circuit, others have a simple corrector without feedback, and still others rely mainly on the curvature of the valve characteristic; some have a blocking oscillator, others a multivibrator. There is variety, too, in the synchronizing means; some still use an integrator, but probably most have a more elaborate arrangement with one or two diodes so arranged that the line pulses are completely removed from the wave.

There is little obvious development in this part of the equipment and from the performance point of view the results obtained in all the various ways seem much the same. The choice of a particular arrangement is often the result of economic factors which are far from obvious. Double-valves are now quite commonly employed and the design of the rest of the set may be such that, if the usual blocking oscillator were used for the frame saw-tooth generator, there would be a spare electrode assembly. It is then cheaper to utilize this as part of a multivibrator and to dispense with the blocking oscillator transformer.







The straight-sided mask is illustrated by the Ferguson 984T (above) and the curved-sided by the Regentone Big 15 5 (right). The "double-D" picture format is used in the Peto-Scott TV168 (left).

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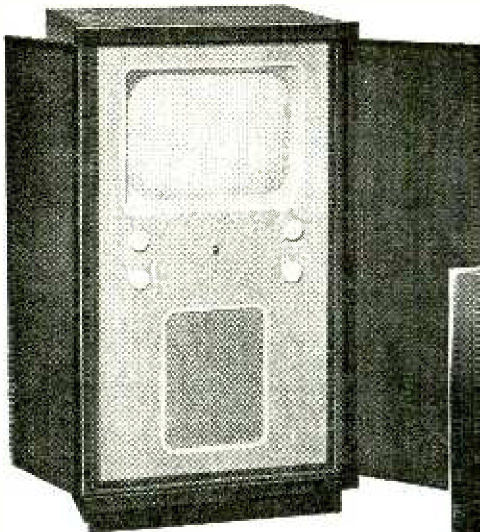
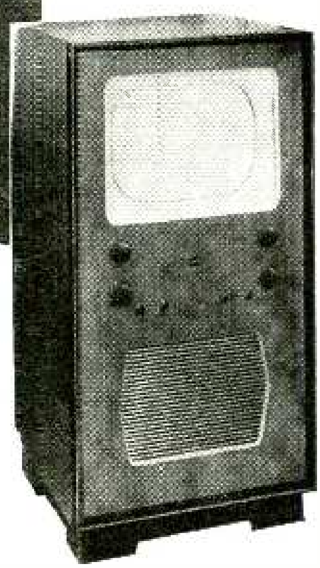
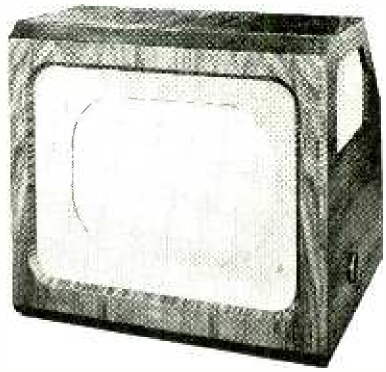


(Left) Philips 1427U with 14-in rectangular tube.

(Right) McMichael table model, showing the unusual position of the controls.



(Below) Stella ST 9212U with 12-in tube.



G.E.C. table model with 16-in tube (BT 6145).

In modern equipment it is often impossible for anyone outside the organization concerned to say just why a particular arrangement is used.

The so-called transformerless set has now become standard and exists in two forms. The a.c./d.c. type is one and this is truly transformerless on its power-supply side. The valve and tube heaters are connected in series and the h.t. supply comes from a half-wave rectifier. Reservoir and smoothing capacitors are of the order of 50-100 μF and an h.t. line of about 180 V is secure. In some sets the smoothing choke can be short-circuited on a d.c. supply, where it is not needed and where its voltage drop is important.

The other category of set is for a.c. supplies only and does actually include a mains transformer. As a transformer it may supply only one or two valve heaters, the rest being series operated, or it may supply all the heaters. In both cases the primary is used as an auto-transformer so that the input to the h.t. rectifier (and the series chain of heaters, if any) can be kept at a reasonably high level on all mains voltages. The rectifier is still a half-wave type and, as in the a.c./d.c. set, the chassis is in direct connection with the supply mains. This requires that the chassis be well protected by the cabinet so that accidental contact with it cannot be made. Considerable attention is now paid to safety. Ventilation and other holes are so placed that no contact with any dangerous part can be made and the grub-screws in knobs are not overlooked.

Fire risks, too, are considered and fuses are used much more than they used to be. They are not always merely a pair in the mains leads, but in addition, subsidiary circuits sometimes have additional fuses. The h.t. supply may have its own fuses, for instance. In some cases, it happens that it is impossible to give a complete safeguard by a fuse; a breakdown in a capacitor, for instance, may result in a resistor being heavily overloaded, but the use of a protecting fuse or cut-out may be impracticable. The trend in such cases is so to place the resistor in the set that damage is confined to the resistor itself.

The permanent magnet retains its position for focusing, electromagnets being now decidedly rare. A recent development, which was shown by Mullard, is the use of Ferroxdur magnets. Two ring-type magnets are mounted with their fields in opposition and the focus field is adjusted by sliding one in relation to the other, so varying the gap between them. This Ferroxdur magnet has already found its way into receivers and is used by Ferguson.

Cathode-ray tubes nearly always have aluminized screens and/or ion traps, so that ion burn should now be a thing of the past. The metal tube is fairly common in the larger sizes and, since the metal cone is live to e.h.t., it requires careful insulation. The tube mounting often includes insulators several inches long and the front end is sometimes held in a moulded polythene ring.

The rectangular tube is also now quite widely used, especially in the table models, since it undoubtedly reduces the cabinet size for a given picture area. With such tubes the quoted size is for the diagonal and a 17-in diagonal rectangular tube gives the same size picture as a 17-in diameter round one.

In spite of the general increase of picture size, therefore, there are few external changes in the appearance of television sets and there is very little alteration in their dimensions. The chief styles are the table model and the console and, for both, the usual material for the cabinet is wood. Moulded-plastic cases are still to be found but appear less prominent than in previous years. The use of a transparent plastic as an implosion guard, however, is very common and is probably more often used now than glass. It is moulded to the contour of the tube face and it very often tinted.

The tinted screen or filter seems to be increasing

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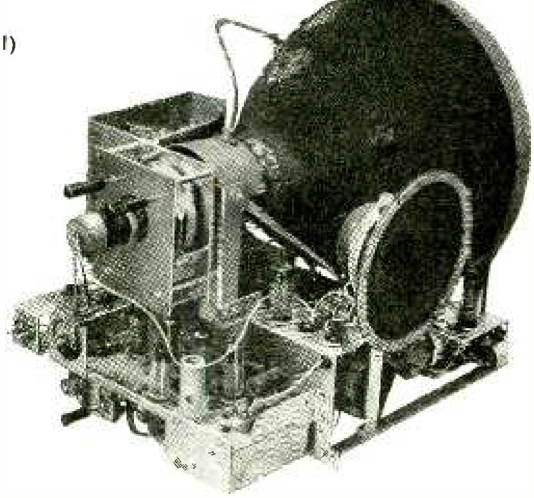

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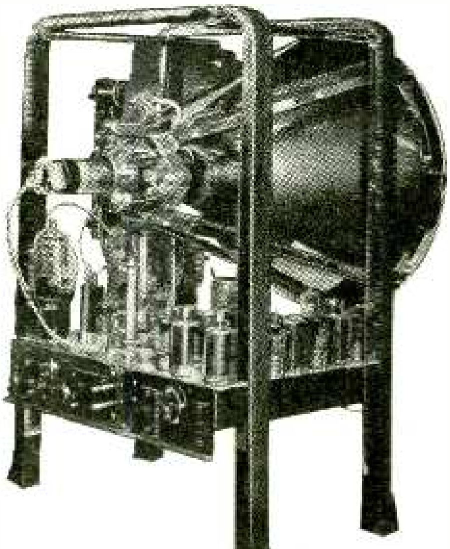

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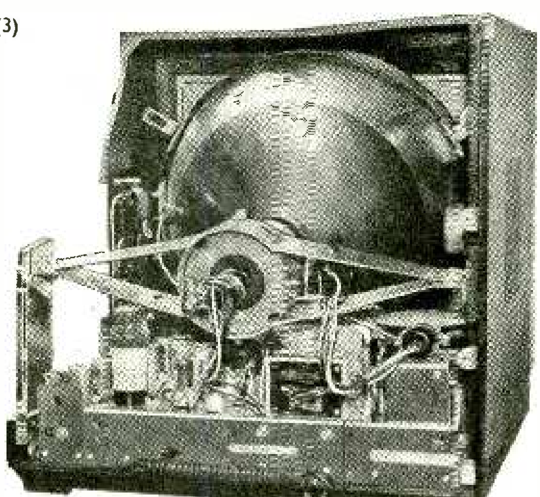

in popularity. There is no doubt that it improves picture contrast when there is a good deal of ambient lighting, but it undoubtedly requires an initially brighter picture. It would, therefore, appear to be detrimental to both tube life and to focus. In view of this it is rather surprising that there are few sets in which the filter is removable, so that the user need employ it only when it is really necessary. Murphy do so in the V204, but they are one of the few who do and the trend is certainly away from this. In some cases the filter is a part of the c.r. tube itself, the tube face itself being tinted, which precludes any possibility of its being removable. The present practice is to use rather lighter screens than hitherto. The majority are of a lightish grey colour, but the dark greys and deep purples, which were common when the filter was first introduced, are still used in some sets. There are still plenty of sets without such filters. About 45 per cent have clear viewing screens, 36 per cent light grey screens and 19 per cent dark grey or purple; 55 per cent have tinted screens.

The shape of the viewing mask is usually a "rectangle" with slightly curved sides and rounded corners. In some sets the sides are straight and only the corners are rounded. A few sets have the so-called double-D mask in which the top and bottom are straight but the two vertical sides are semi-circular. This was introduced about two years ago, but only six sets with it were noted this year.

The two important changes which are obvious are the general increase in picture size and the flatter tube faces. Only two models with 9-in tubes were at the exhibition this year! Nearly 60 per cent of the sets had 12-in tubes and 30 per cent had 14-in or 15-in. The remaining 10 per cent had tubes in the 16-in, and 17-in sizes and there was one, the H.M.V. model 1820, with a 21-in tube. Of sets sold during June 1952, the 9-in tube accounted for 7 per cent and the 12-in for 68 per cent.

The increase in size is so general that the 9-in screens now look tiny and the 12-in seem a bit small. The comparison that one makes at an exhibition is, of course, a very artificial one and under average domestic conditions the 12-in screen is about right. The larger screens are best suited to those having rather bigger than average rooms.

No-one can yet say what picture size will eventually become standard for direct viewing. Apart from technicalities, the economic factor is very important. One may guess that it will settle down at something like 12-15 inches.

The impression given by the receivers in operation at the exhibition is of a general improvement in performance. It is hard to judge the advances that have been made without direct comparison, but one got the impression of an appreciable improvement in definition and in tonal range. These are things which come about through improved design and mainly through closer attention to detail both in design and

(1) Chassis of Ferranti television receiver. The framework holding the focus magnet is of non-magnetic material.

(2) Ekco T161 chassis and tube mounted on special display stand. The way in which the focus magnet and deflector coils are carried on struts from the front mounting of the tube is clearly shown.

(3) Murphy V204 with part of the cabinet cut away to show the interior. The tube is clamped at the front and the focus and deflection assembly is carried by brackets attached to the side of the cabinet.

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manufacture. They are not things which are evident on inspection of the apparatus or its circuitry.

This improvement in performance is also evident in the mechanical form of many receivers. There is much evidence that sets are now being well "engineered." The rigidity of the chassis and the tube mounting has been generally increased and the accessibility for maintenance has been improved. There is a noticeable tendency to keep the c.r tube separate from the chassis and to mount it, with the deflecting and focusing arrangements, in the cabinet as a separate unit.

Ekco, for instance, clamp the tube at its large end between a support ring and the implosion guard. Four light, but stiff, struts from this meet on a ring around the neck, which ring supports the deflector coils on one side and the focus magnet on the other. The whole forms a compact and rigid assembly which is mounted as a unit in the cabinet.

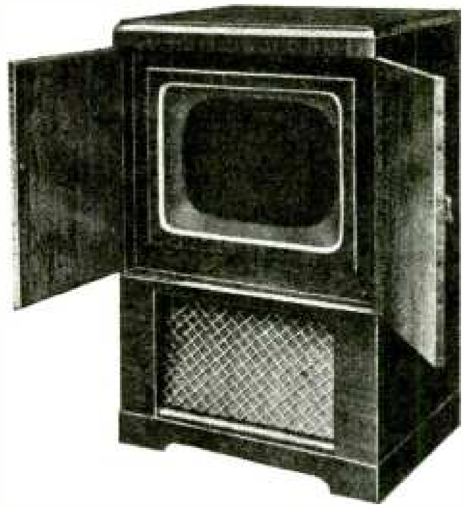
A good many firms showed projection television receivers. They are basically the same as those which have been available now for some years and employ the Mullard optical system and c.r. tube. Detail improvements, particularly in the e.h.t. supply and in viewing screens, have resulted in a noteworthy improvement in performance. Although most sets are of the back-projection type with everything inside the cabinet, there are quite a few front-projection sets. In these the viewing screen is hung on the wall and the picture projected on to it. For the best results viewing must take place in almost complete darkness, whereas the back-projection sets are but little affected by ambient lighting. Generally speaking, the back-projection sets are for domestic use, whereas the front-projection are more suitable for clubs and large assemblies where viewing can take place under more cinema-like conditions. The pictures, too, are bigger with a diagonal up to 5 ft.

Projection receivers are, of course, no different in their basic form from direct-viewing types. About the only differences are in the video stage, where rather greater output is needed, in the e.h.t. circuits and in the need for simple tube protection circuits. The 25-kV e.h.t. supply is invariably obtained from a special unit operating on the ringing-choke principle.

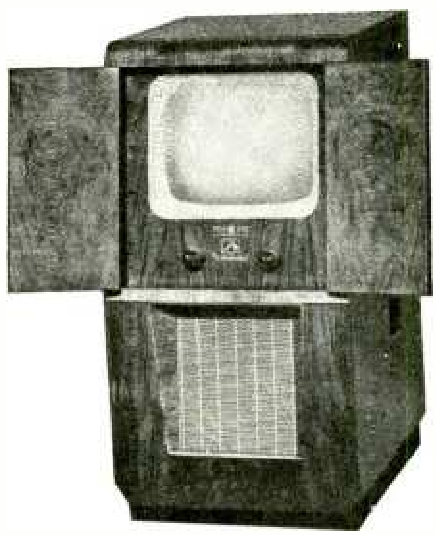
Whatever set is used it needs some form of aerial and feeder. Opinions are still divided about the relative merits of twin-wire and coaxial feeder and both are still used.

Occupiers of rented premises sometimes find it a little inconvenient to bring a television feeder through the walls or window frames of the building. As a solution Wolsey have evolved a window aerial coupler consisting of two small cylindrical-shaped units attached to opposite sides of a window pane by suction cups. The coaxial feeder is connected to one and the lead from the receiver to the other. Each unit contains a tuned coil and the two are coupled together through the glass of the window pane. They thus form an r.f. transformer giving a signal transfer by inductive coupling. There is no direct connection between the two, so that the sheath of the outdoor feeder can be earthed to reduce any risks from lightning.

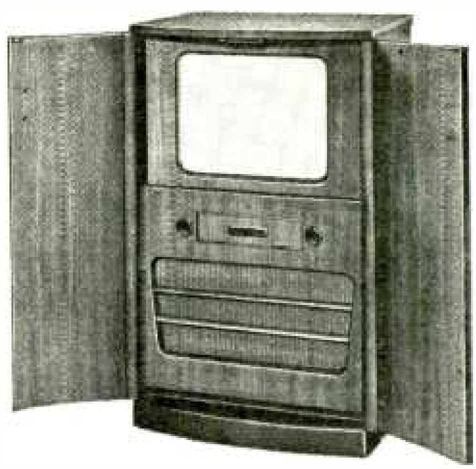
Television aerials themselves are in the main unchanged. There are simplified types for areas of very high field strength, but development is largely in fringe-area types. Signal-to-noise ratio is here a major factor and various means are being adopted to improve it. Belling and Lee have produced a very



Pye FV2C with 14-in tube, dark screen, and flywheel sync circuit.



H.M.V. 12-in tube console Model 1816.



Ferranti T1625 projection model with 15-in by 11¼-in picture

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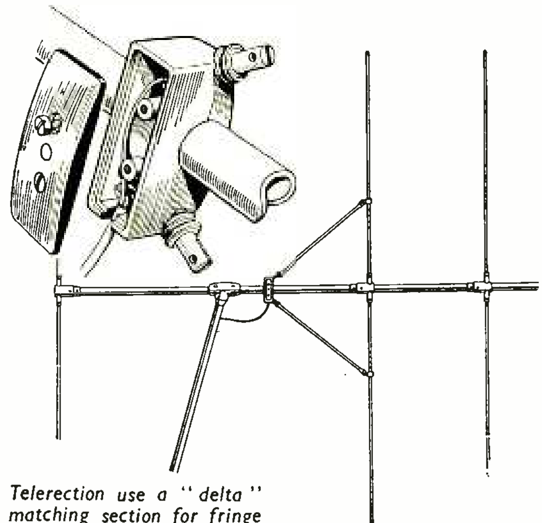
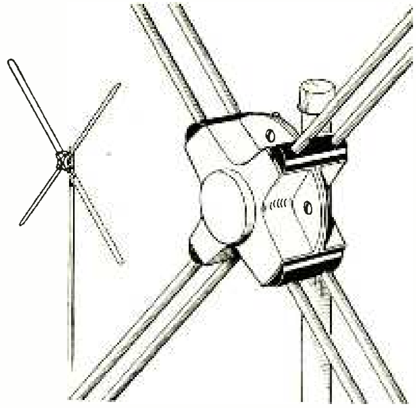
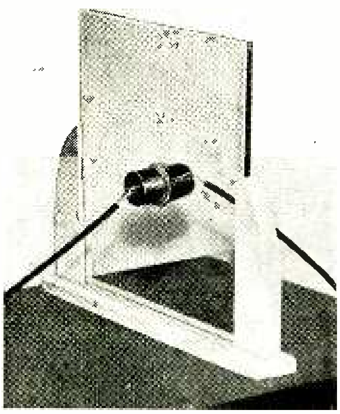


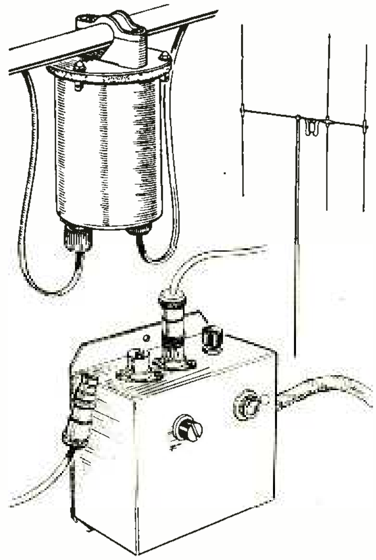
Telerection use a "delta" matching section for fringe area aerials.



Aerialite Dublex television aerial uses crossed folded dipoles.



Left: Wolsey Window Aerial Coupler is fixed to the window pane by suction cups, no holes are required.



Right: Belling-Lee head amplifier and power unit. Inset: Mounting of amplifier on aerial.

compact pre-amplifier, appropriately named a head amplifier, since it is mounted at the top of the mast supporting the aerial array. A single-stage push-pull earthed-grid amplifier, giving a gain of 8 db, is employed and power for the amplifier is fed along the coaxial feeder in the form of 33 volts a.c. so that no additional cables are required. In the head amplifier is a small rectifier and a.c./d.c. technique is adopted.

Another way by which a better signal is achieved, again by improving the signal-noise ratio, is by paying particular attention to the matching of feeder to aerial. Telerection have adopted the "delta" match in place of a "T" match employed hitherto as it is said that more satisfactory matching is possible and consequently the overall gain of the system is improved.

Development work on aerials for normal service area use has not stood still and an entirely new aerial has been introduced by Aerialite. This is known as the "Dublex" and consists of a pair of folded dipoles arranged in "X" formation. In this model the dipoles are interconnected and both joined to the feeder for anti-phase operation. A forward gain of 6 db with a back-to-front ratio of 25 db are claimed for it.

Aerial makers are supporting their claims by means of polar diagrams showing the measured responses of the various aerial systems and it is interesting to note that in the case of the Aerialite "Dublex" the response to both sound and vision signals is sensibly the same. It is clear, therefore, that the type of construction adopted provides a satisfactorily wideband system.

SOUND RECEIVERS: HOME AND EXPORT

NUMERICALLY the table model superheterodyne is still the most important sound receiver, and of the hundred-odd models shown, fully 25 per cent are new this year. Many of these have been produced to an economical specification which omits non-essentials without sacrificing the quality of vital components, and are priced between £20 and £25, including tax. Typical of this trend are the Bush AC31 and K.B. Type H30.

Another marked trend is towards the use of shallow cabinets with a large frontal area to give the best

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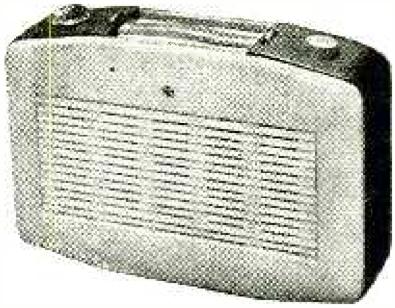
possible quality of reproduction at the lower frequencies. New receivers in the category include the Ferranti 225, the G.E.C. type BC583, Philips 411A, Pilot 75, Pye PE60, the Sobell 553 and the Stella type ST151A.

In the Ferranti 225 the internal frame aerials are switched out when the set is used with an outdoor aerial. Many sets use either frame or plate aerials which take the place of the outdoor aerial when circumstances permit.



Designed for operation from a.c. mains or batteries, the Pye P65MBQ has an 8in loudspeaker.

Alba "7-0-7" portable radio-gramophone for battery as well as mains operation.

There are signs that manufacturers are giving more attention to selectivity, which is assuming increasing importance, particularly in the south of England, on account of the overpowering strength of some medium-wave Continental stations after dark. In the new Murphy A182 the i.f. response has been adjusted to give a steep-sided characteristic, with reasonable bandwidth and a sharp cut-off.

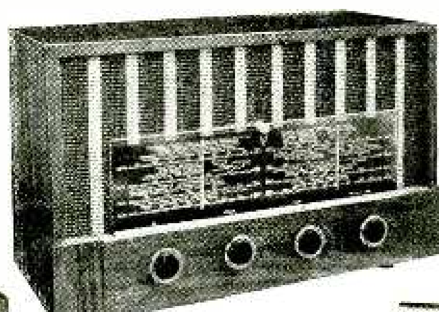
Push-button selection of a limited number of stations (usually three) is a feature of several of the table models. In the new G.E.C. BC5839, calibrated slides at the back of the set are provided for setting up the selected stations.

Table model receivers for export follow the broad lines of home models so far as their basic circuits are concerned, but employ components with extended temperature rating and are treated to resist corrosion and be less palatable to insects. Extra short-wave ranges, usually bandspread, are provided and the long-wave range is omitted. Calibration if often in frequency rather than in wavelength and cabinet styles are more colourful than is deemed "safe" for the home market. Many sets are available for operation from a 6-V accumulator through a vibrator, or from "all-dry" batteries as well as from mains. The new Masteradio D133, for example, is available in alternative versions for all three of these methods of power supply. The Pye P60, which, incidentally, is now available for the home market, has an export version for 6-V operation and has a liberal specification with no fewer than 11 wave ranges. Another outstanding export receiver, in this case for "all-dry" battery operation, is the new Vidor "Bandspread 8" (Type CN423). The frequency changer is a heptode working in conjunction with a separate high-stability oscillator. Feedback is applied over the output stage.

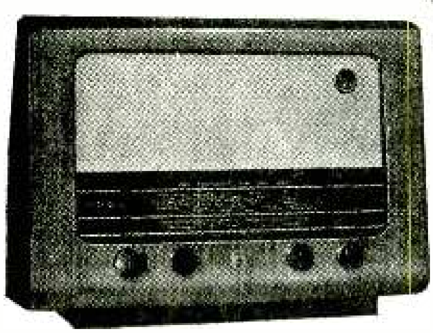
The demand for full-sized table models working from dry batteries only is by no means confined to overseas buyers, and a new high-quality receiver (Model 258B) made by Ferguson has a 1-watt q.p.p. output stage

Where low first cost is a consideration and running expenses must be kept to a minimum, the battery set can again supply the answer, as has been demonstrated by Ever Ready in their two-valve Type "H" receiver. This costs only £7 13s 1d (complete with aerial and earth wires, which are considered essential) and gives 500 hours service from a B103 combined l.t. and h.t. battery.

In households where television is the main interest, the sound receiver is often a portable maid-of-all-work which can be used on mains at home and on batteries out of doors. Between 30 and 40 models are available in manufacturers' current lists and roughly a quarter of these are new at the Show. The new Murphy BU183 is compact and incorporates an interesting battery economy circuit which is continuously in operation. In series with the bias resistor, which is of a higher value than normal, is a small metal rectifier to which a portion of the a.f. output is applied from the anode of the last valve. The rectified voltage is smoothed and opposed to the standing bias, so that the net bias is



Vidor "Bandspread 8" (Type CN423) "all-dry" export receiver.



(Left) Philips Model 411A with shallow cabinet.

(Right) Pye Model PE60, now available for home as well as export.

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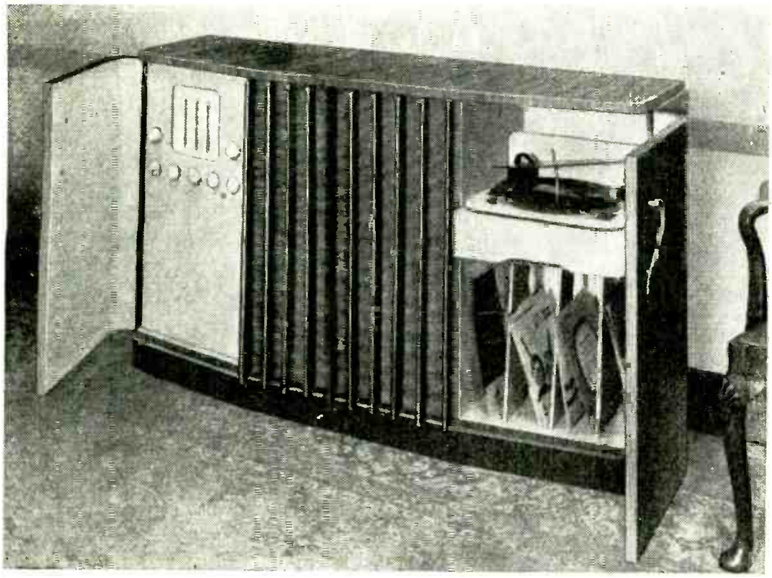
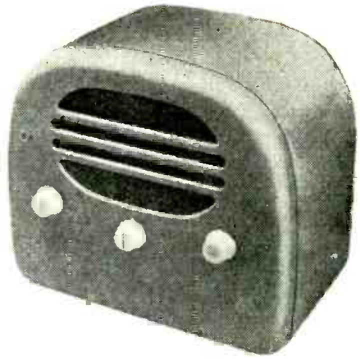


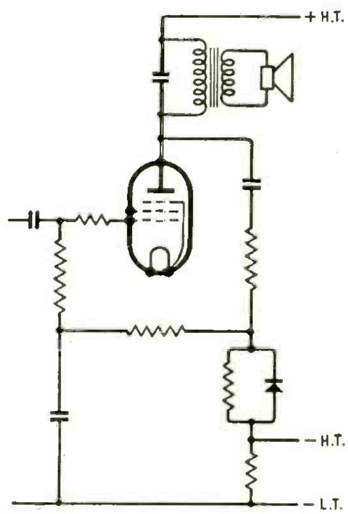


Ever Ready two-valve "all-dry" battery receiver (Type "H") and (left) A new high-quality radio-gramophone, the Ferguson "500."

reduced towards optimum as the power output increases. The Pye P65MBQ, which is designed for battery or a.c. mains operation, is notable for the fact that an 8-in loudspeaker is used in a plastic cabinet which does not give the impression of undue size. G.E.C., in their new BC4444 mains/battery portable, favour the attaché case form in which the battery switch is interlocked with the lid; the weight is 8 lb. Another new portable of this type is the Pamphonic 903 which is for battery operation only. In the latest version of the Ferranti 825 it is interesting to note that aerial and earth terminals have been provided specifically to meet the needs of those who wish to work the set inside a metal-panelled caravan! A mains-battery portable which invites comparison with communication-type receivers is the Champion 781, for which a sensitivity of better than 6μV is claimed. This 7-valve receiver, designed primarily for export, has r.f. amplification on all wavebands and uses a telescopic rod aerial on short waves. When operated from mains the back automatically opens to provide adequate ventilation. A switched battery economy circuit is provided and there is also a switched dial light.

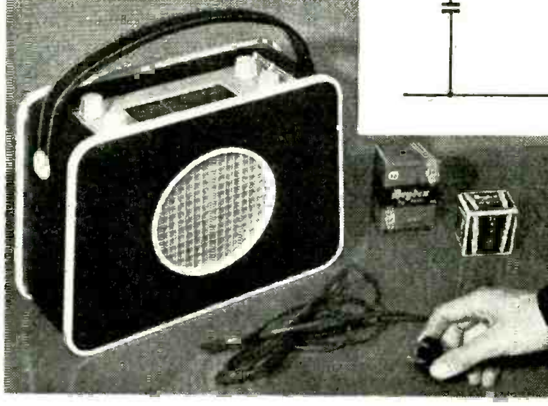
Three portable radio-gramophones were shown; the Pye P32QTG (introduced last year), the Decca "Portrola" with 3-speed turntable, and the Alba "7-0-7." The latter is designed for operation from batteries as well as from a.c. or d.c. mains and has a Garrard spring motor. The motor board is hinged and a half-turn on two screw catches gives easy access to the batteries and the 4-valve radio chassis. An export version is available with medium and one short-wave band in place of the standard medium and long waves.

The sustained public interest in high-quality reproduction is reflected in the large number of new console radio-gramophones which have made their début at the Show. Of the 70-odd models shown nearly 20 were new designs. All the new H.M.V. and Marconiphone models make use of a new three-speed record changer with interchangeable centre spindle to play 45-r.p.m. 7-in as well as 78- and 33⅓-r.p.m. 10-in and 12-in records. In the most expensive H.M.V. radiogram (Model



An automatic battery economy circuit is a feature of the Murphy BU183 mains/battery portable.

Champion 781 mains/battery export portable with r.f. amplification on all wavebands.



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1612A) a total of 15 valves is used and two special 13½-in elliptical loudspeakers are used to give effective distribution of the acoustic output.

Two important alterations have been made in the acoustic specification of the Dynatron radio-gramophone; the bass chamber has been modified to give forward radiation from the vent, and the extreme top can be optionally extended when circumstances permit, by switching in a special treble loudspeaker unit. The "Ether Conqueror" radio chassis (which can be purchased separately for £136 6s) has an overall gain which has proved excessive in some applications, and a pre-set i.f. gain control is now fitted as standard. This is not the usual bias control, but is a feedback arrangement which avoids disturbance of the response characteristic. Another new refinement is a bi-metal-controlled, temperature-compensating capacitor in the oscillator circuit. Ferguson can justly claim to have entered the front rank of radio-gramophone manufacturers with their new "500." This employs the cathode-coupled output stage used in the "300" model described last year, but with larger valves (EL37) and the total harmonic distortion is now 0.1 per cent at 6 watts, 0.35 per cent at 10 watts and 1 per cent at 14 watts. A combination of 12-in and 5-in loudspeakers handles the output and the cross-over is at 1,000 c/s. An extended bass response is ensured, without coloration, by a large frontal area and a two-section acoustic chamber. The cross-over network is loaded to equalize variations of the loudspeaker impedances with frequency and the circuit is claimed to minimize the effects of phase shift commonly experienced with conventional cross-over circuits. Steep- and gradual-cut filters are associated with the tone control to give the optimum performance on records which cannot be played with the full frequency range. The pickup is a special crystal with a flat response up to at least 12 kc/s.

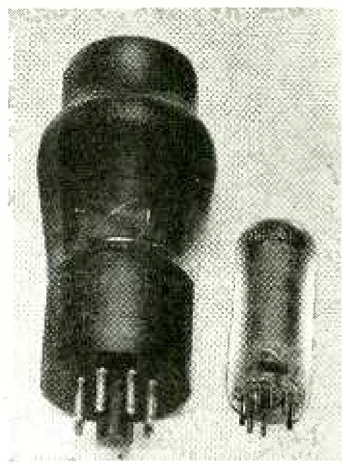
Only two new table-model radio-gramophones made their appearance, the Sobell 513TG and the Invicta 58. The latter must be unique in having a trawler band (75-200 metres) in addition to short, medium and long-wave ranges. An unusual loudspeaker arrangement was noted in the Sobell 613AG console radio-gramophone which has twin 8-in units mounted in the corners at the front with the record storage compartment in the centre.

Most firms include in their catalogue which might be termed "production high-quality" console radio-gramophones at prices in the region of £60-£70. These give a standard of performance which is in keeping with recent advances in recording techniques and will appeal to those whose listening experience has reached the stage where the average table model receiver with record-player has apparent limitations.

VALVES AND CATHODE RAY TUBES

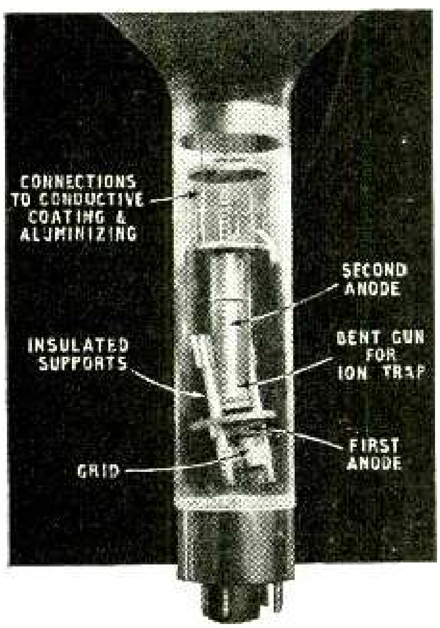
IT is not exactly surprising to find that practically all the new receiving valves being produced nowadays are either designed specifically for television or with a very wide-open eye to their possible use in such circuits. Indeed, with manufacturers describing them glibly as "video pentodes," "line-scan output valves," "booster diodes," "e.h.t. rectifiers" and so forth, one almost tends to forget that they are, when all's said and done, just ordinary valves. But apart from the question of terminology there is no doubt that these valves all reflect in their electrical and physical charac-

Right: Ediswan 17-in rectangular cathode ray tube, type CRM171.



Above: Size comparison between Brimar 6V6 beam tetrode and its modern miniature equivalent the 6BW6 shown on the right.

Below: Electrode structure of Mullard cathode ray tube (large-size demonstration model).



Left: Cossor ICP1 miniature cathode ray tube for waveform monitoring.

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teristics the trend of design of the modern television receiver.

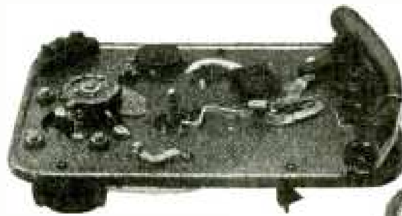
At the moment the prevailing trends are towards a.c./d.c. circuits, to give receivers that are small, light and cheap, and wide-angle cathode ray tubes to satisfy the continual demand for bigger pictures. Consequently the newer valves are all miniature types, with 0.3-amp heaters designed for series running, with characteristics that make the most of the necessarily low h.t. supply, and with outputs capable of driving the wide-angle c.r. tubes. Most of them are on the B9A base rather than the B7G. This is partly because the extra pins are needed for multi-electrode and double valves and partly because the slightly larger envelope allows of greater power ratings—it is the glass alone which sets a limit to the dissipation.

One new valve at the Show which typified this trend was the Osram N339 power pentode, intended mainly for use as a line time-base output valve in a.c./d.c. television receivers. It is on the B9A base and has a 0.3-amp 20-volt heater, and in spite of its small size (2¾in high and ⅞in diameter) it will deliver a peak anode current of about 300 mA at an anode voltage of only 85. The mutual conductance is 9 mA/V and the maximum power dissipation just under 15 watts. This valve, like many of its contemporaries, has been designed with the "knee" of its anode characteristic at a very low voltage, so that a large anode current swing can be obtained with a low anode voltage—and also with a small power dissipation.

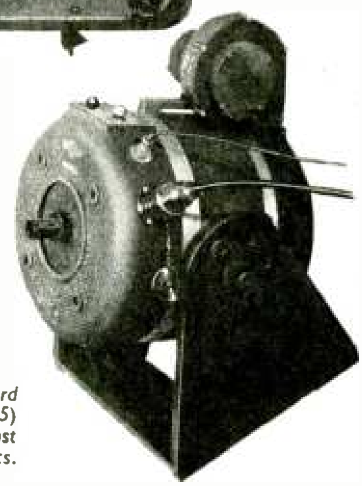
In the realm of the r.f. amplifying valve, however, the impact of modern television technique has not produced any startling developments, for there were plenty of types in existence already that satisfied all the requirements of wide-band amplification. Even the necessity of operating these valves at low anode voltages in a.c./d.c. sets does not have any really detrimental effect on their characteristics. The general trend, then, is quite a normal one towards higher mutual conductance, higher input impedance, lower inter-electrode capacitances and lower noise levels. A typical example at the Show was the new Brimar 6BW7 pentode, suitable for r.f., i.f. and video amplification. Again it is a miniature all-glass valve on the B9A base and has a 6.3-V, 0.3-A heater. With an anode voltage of 180 volts the mutual conductance is 9 mA/V while the input impedance at 50 Mc/s is 14kΩ. The input capacitance is 10 pF and the output capacitance 3.5 pF.

Considering the miniature valve generally, there is evidence of some very great improvements in all-round performance and reliability in the last year or so. No longer is it the precocious problem-child of the industry, and no longer do cautious engineers regard it with suspicion. Indeed, a study of some of the latest types reveals that they are now considerably better than the old normal-sized valves from which they were originally derived. Undoubtedly, the reason for this has been the large demands of the television set-making industry, which have forced manufacturers to pay special attention to the design and mass-production of these valves—and made such attention well worth while.

Developments in television cathode ray tubes are still largely controlled by the simple human failings of Mrs. X of Acacia Grove, who, when she goes to buy a television set, is determined to have a bigger picture than Mrs. Y next door. The thing of the moment seems to be the rectangular tube with a 17-in diagonal, and most of the well-known manufacturers had their own versions on show at the Exhibition, although not all of them were actually in production. These were all wide-angle tubes with anode voltages in the region of 15 kV.



Garrard 3-speed gramophone unit (Model T) with turntable removed.



Goodmans Type 8 600 vibration generator delivering an r.m.s. force of 250 lb.

H.M.V. 3-speed record changer (Model 2125) with special centre post for 7-in, 45-r.p.m. discs.

The next size down is the 16-in tube with an anode voltage of about 12 kV, and at the Show it was represented by one new all-glass type and two steel-cone types. In spite of the metal shortage the steel cathode-ray tube still seems to be keeping its foot in the door, so to speak, and undoubtedly it deserves recognition for the very attractive feature of its light weight. The 16-in type, for example, weighs only 14 lb as against the 20 lb of its all-glass counterpart. But the steel tube is more expensive at the moment, and only when Mrs. X drives the screen diameters up to about 20in and all-glass tubes become difficult to make, will it begin to show an advantage in price. (The solitary 21-in tube at the Show was a steel-cone type.)

Coming down to the more familiar 15-in tube, one of the latest models at the Show was the Ediswan CRM152B. This was interesting by virtue of the fact that the glass face of the screen was tinted grey to give the same effect as an anti-halation filter placed in front of the tube. (The idea may have sprung from a recent suggestion that grey-tinted phosphors might be used.) But, of course, although this scheme undoubtedly improves the picture in the same way as a separate filter, it still suffers from the inherent disadvantage of reducing the light output of the screen.

The smallest of the new wide-angle tubes on which

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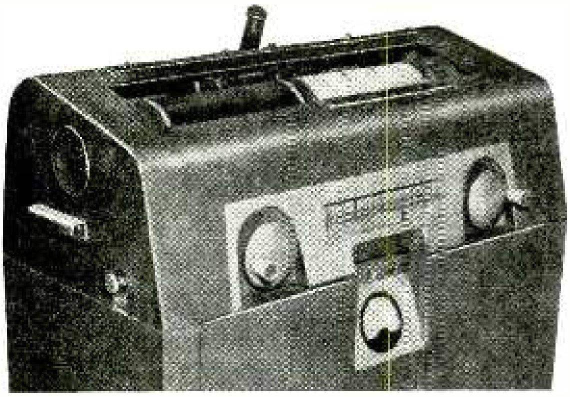
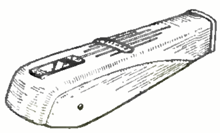
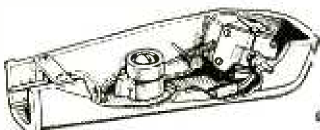
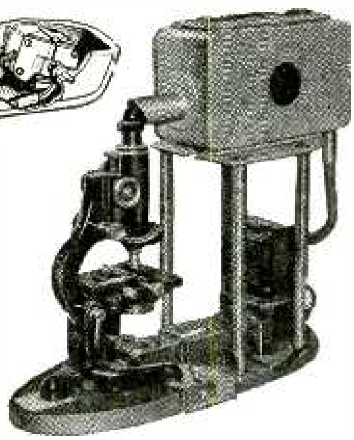




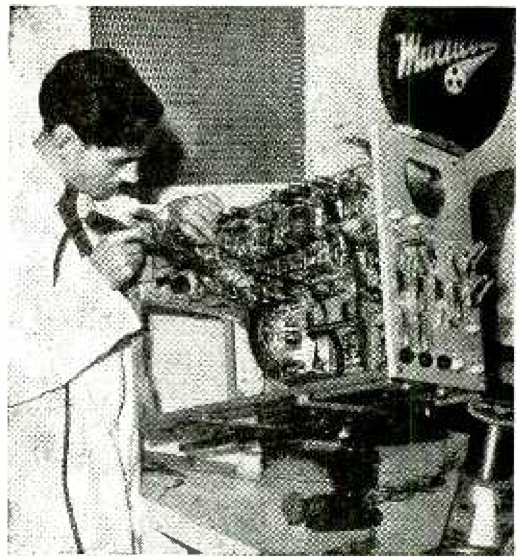
Above: Roneo electronic stencil cutter showing the cylinders carrying the stencil (left) and the original (right).



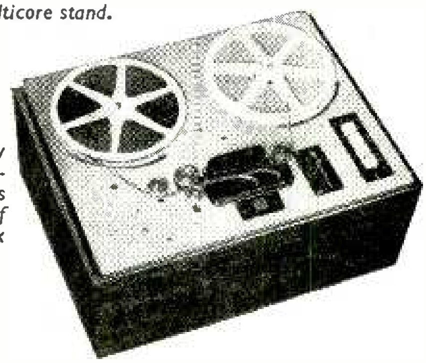
Above: Collaro "Orthodynamic" magnetic pickup with twin osmium-alloy stylus tips.



Right: Pye miniature television camera used as a 625-line television microscope.



Demonstration of soldering on a Pye television camera at the Multicore stand.



Right: Fully automatic push-button controls are a feature of the new Truvox tape deck.

manufacturers are now concentrating seems to be the rectangular type with a 14-in diagonal. It gives an effective picture area nearly 40 per cent greater than that of a 12-in circular tube, and the cubic space it occupies in the cabinet is about 40 per cent less. The latest versions at the Show were the Ferranti TR14, with an octal base and 4-V heater, and the Mullard MW36-22, with a B12A base and 6.3-V heater. Both are operated with about 10 kV on the anode and require a modulating signal of the order of 30 V. The TR14 carries on the tradition of all previous Ferranti tubes of doing without an ion trap, which, the makers say, is not necessary if the tube is properly de-gassed to prevent the formation of ions in the first place. Nevertheless, the screen has an aluminized backing which would serve as a protection against ion burns if by some mischance the tube were not properly de-gassed.

With all the attention that is being focused on the cathode ray tube as a means of displaying television pictures, one almost tends to forget that it is also a useful device for observing waveforms. However, oscilloscope tubes were quite well represented at the Show. Two of the latest were the 1608CCHE double-gun tube made by G.E.C. and the 1CP1 miniature tube by Cossor. The last-mentioned is remarkable for its small size (1-in diameter screen) and for the fact that the focusing of the beam is automatic and only one anode potential is required (about 500-800 volts).

OTHER EXHIBITS

ALTHOUGH the Radio Show this year gave rather less than an adequate picture of the scope of British activities in electro-acoustics, such exhibits as were to be seen—and heard—were of more than usual interest. G.E.C. gave one of the best demonstrations of two-channel stereophonic, or, as they prefer to call it, three-dimensional sound reproduction so far heard. Intended primarily to demonstrate G.E.C. resources and skill in high-quality reproduction, the equipment comprised G.E.C. "Quality" 30-W amplifiers (using KT66 valves) and moving-coil loudspeakers of radically new design developed by the Research Laboratories, Wembley. The cone diaphragms are of metal terminated by a corrugated surround of plastic damping material and are pierced and pressed up to form louvres at strategic points on the diaphragm. There is also what appears to be a form of high-note diffuser in the apex of the cone. It is claimed that the metal diaphragm causes less intermodulation than paper types and that the difficulty of obtaining a smooth response at high frequencies has been solved. The demonstrations certainly support these claims. Each loudspeaker consists of three units mounted in a vented cabinet, which seems to be remarkably free from coloration in the bass.

Another well-attended demonstration was that of Goodmans Industries who showed the relative merits

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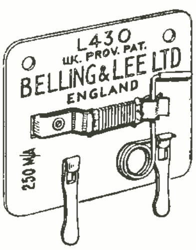
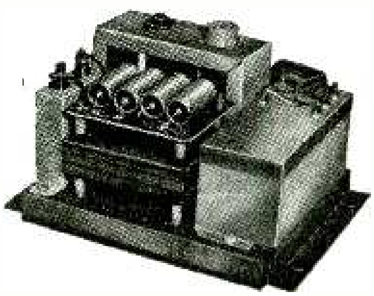
of all their principal units and baffles. Two new high-quality 8-in cone loudspeakers have been introduced by this firm. They are the Axiom 101 and 102, the former with 13,500 gauss and the latter with 16,000 gauss flux density in the permanent magnet gap. A convex centre cone radiates the higher frequencies, and the frequency range quoted is 50-10,000 c/s. Goodmans also specialize in moving-coil generators for vibration tests and in addition to the small instruments for valve electrode testing, and intermediate types for light engineering components, they have now developed a Model 8/600 capable of an r.m.s force equivalent to 250lb for exciting aircraft frames and similar structures. Two impedances, suitable for excitation from an alternator at low frequencies, and a valve amplifier at higher frequencies, may be selected by a changeover switch. The field is provided by a permanent magnet and the moving coil is air-cooled by a built-in blower. A pickup unit mounted at the "delivery" end of the driving spindle is provided for monitoring the waveform of the motion.

V.H.F. portable radio-telephone made by G.E.C.

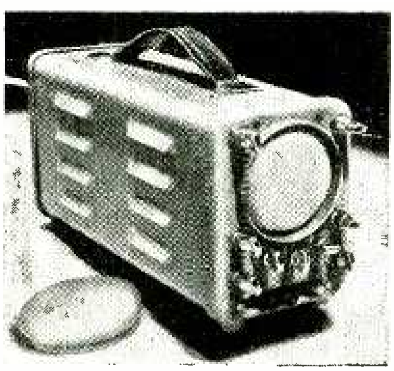
Right : Waveforms television c.r. tube tester and reactivator.



Above : Belling-Lee overload cut-out, 250 mA type.



Above : Internal view of Valradio lightweight vibrator power pack used in the Comet jet airliner.



Left : Cossor miniature portable oscilloscope with tube protecting cap.

Among new record-playing mechanisms a compact new 3-speed turntable unit (Model T) by Garrard was notable for the single-ball tone arm bearing giving free lateral movement and for the independent stylus pressure adjustment which supplements the automatic change of pressure as the pickup head is rotated for standard or long-playing records. The new H.M.V. 2125 plays up to eight 10-in or 12-in 78-r.p.m. records mixed, up to ten 10-in or 12-in mixed 33⅓-r.p.m. or 45 single records. Up to eight 7-in 45-r.p.m. discs can be played by using a special centre post. The wide range of Collaro players and record changers remains substantially as before, but it is interesting to note that the "Orthodynamic" (magnetic) lightweight pickup for 78- and 33⅓-r.p.m. records is now fitted with twin styli of hard osmium alloy which is immune from fracture and is stated to have self-polishing properties when used on modern record materials.

A three-motor drive is a feature of the new Truvox tape deck, shown by the associated Rola-Celestion Company. The tape loading does not involve threading, and controls for record, playback and fast forward or rewind are by push button. An additional feature is a separate push-button "instantaneous" brake. The half-track recording head is wound for a high-impedance signal source with a low-impedance tap for bias and the erase head has a low-impedance winding.

Undoubtedly the most original exhibit on the R.I.C. electronics stand was a machine, made by Roneo, Ltd., by means of which it is possible to reproduce pictorial matter on duplicating stencils. This means that the well-known Roneo duplicating process is no longer restricted to the sort of thing that can be cut directly into the stencil by a typewriter or stylus, but can be used for reproducing photographs, newspaper and magazine pictures, typeset matter, pencil and water-colour drawings—in fact almost any kind of original.

The general principle of the machine is reminiscent of phototelegraphy. A pattern of tiny holes is cut in the stencil by an electric spark which is controlled by a photocell scanning the variations of light and shade of the original. The intensity of the spark, and consequently the size of the hole which allows the ink through, varies in proportion to the darkness of the original. As in phototelegraphy, the original is fixed to a revolving horizontal cylinder and is scanned in a spiral by the photocell tracking slowly across from one side to the other. Rotating on another cylinder on the same shaft is the stencil, with a tungsten wire electrode moving across it in synchronism with the photocell—the spark jumps from this electrode through the stencil (made of a carbon material) to the metal surface of the cylinder underneath. The fluctuating output of the photocell is used to amplitude-modulate a 20-kc/s carrier frequency, which is amplified and applied to the spark gap from a 30-watt push-pull output stage. Thus there is a spark at each half-cycle peak of the carrier, and its intensity depends on the peak level produced by the modulation from the photocell. Scanning is done at 500 lines to the inch, which is a good deal finer than in phototelegraphy, so it is possible to reproduce the most subtle variations of light and shade by this process.

In the way of soldering materials, there were some useful new products to be seen this year on the Multicore stand. Notable amongst them was a range of exceptionally fine wire solders extending from 24 s.w.g. down as far as 34 s.w.g. All of them, even the 34-gauge, contain three separate cores of flux and the proportion of flux to solder is the same as in the larger-sized wires. Then there was a soldering wire composed of tin, lead and cadmium with the low melting point of 145° C, and another one, made of pure tin, with the high melting point of 232° C. Suitable for soldering flat pieces of metal together was a "liquid" solder consisting of powdered alloy and flux. The idea is to paint it on and then heat the work until the solder flows. Also shown on this stand were examples of joints made with coloured-core solder (which Multicore claim to have introduced many years ago); slugs, pellets and pre-forms for mass-production soldering; and various fluxes dissolved in alchohol.

Worthy of mention were the pin-protectors for miniature valves shown by Brimar. The valve pins wedge into a circular groove cut in a small pellet of flexible plastic material.

The idea of revivifying a valve that has lost its emission by over-running, or "cooking," the filament is not new but so far as we know it has not hitherto been applied to television tubes. The high cost of a replacement makes any scheme that might give the tube a new lease of life worth while trying, especially as nothing is lost if the tube fails to respond to treatment.

A piece of apparatus for this purpose has been developed by Waveforms. It is a little more than a reactivator as it contains a sensitive micro-ammeter which records the actual emission of the tube and shows what progress is being made to restore the emission to a usable value; about 80 to 100 μA is said to give acceptable picture brightness. Tests can also be made of heater-cathode insulation, of heater continuity and for short-circuits on any electrode. Described as the "C.R. Tube Tester-Reactivator" it is intended mainly for dealers' use. The tube can be tested without taking it out of the set.

A genuinely portable miniature oscilloscope has been introduced by Cossor for general-purpose use. Known as the Model 1039, it contains a $2\frac{3}{4}$-in c.r. tube, a single stage work amplifier switchable for high gain at narrow bandwidth or low gain at wide bandwidth (3.5 Mc/s), a time base covering 10 c/s to 50 kc/s and provision for an external time base if required. The total weight is $9\frac{1}{4}$ lb and the size $5\frac{1}{2} \times 4\frac{1}{2} \times 11\frac{1}{2}$ in. It is a.c. operated and entirely self-contained.

A new television waveform generator has made its appearance, the makers are Telequipment and it provides both sound and vision signals. The test pattern is the usual series of vertical and horizontal bars but accompanied by gradations in intensity of the horizontal bars. A variety of waveforms can be produced and the receiver checked for line and frame hold, interlacing, possibility of ringing, linearity and most of the tests needed on a television receiver in the absence of a signal. Models are available for British, Continental and American systems.

Communications equipment was almost non-existent this year but G.E.C. had a few new items. Some minor modifications have been made to their communications receiver and in its new form, which incidentally is not changed outwardly, it is known as the Model BRT400D. They have also introduced a small pack-type radio telephone for operation as a walkie-talkie in the 70- to 100-Mc/s band. It gives an output of 0.25 W into a telescopic integral vertical aerial, uses frequency modulation and is operated from a 6-volt accumulator using a vibrator for h.t. supply.

A new device for protecting equipment subject to surges has been evolved by Belling and Lee. It is an overload cut-out and operates on the principle that heat generated in a resistance expands a bi-metal hairpin strip causing it to open and release a spring-tensioned contact. Several of these small cut-outs can be distributed throughout a set, or grouped for accessibility, so giving local protection to components in the event of a short circuit, or a damaging fault arising. They can be wound for nominal current ratings of 100 mA to 1 A and cut out at 100 per cent overload of the rated current.

Air Radio Developments

Trends in Design as Shown by Equipment Exhibited at Farnborough

DURING the period of the National Radio Show at Earls Court another display of radio equipment was being held at Farnborough where the annual flying exhibition organized by the Society of British Aircraft Constructors was in progress. As might be expected this display was of a specialized kind, being devoted to radio apparatus for use in aircraft or directly connected with flying in one way or another.

Radio aids to navigation figured prominently among these exhibits and a number of quite different systems are being experimentally tried, but so far no one particular type stands out ahead of the others. Sooner, rather than later, a decision must be reached as to the best type for general use, since it is not economical for aircraft to carry equipment which merely duplicates the functions provided for by some other piece of apparatus.

An aid that has certain merits and which has made considerable headway in the United States and is now coming into use on the continent of Europe is a system known as VOR (v.h.f. omni-directional radio range). It enables an aircraft to fly on a definite course or obtain a bearing on one or more ground beacons without having to carry complicated or bulky equipment.

In the VOR ground beacon developed by Marconi's Wireless Telegraph Company two signals are radiated on a common carrier in the band 112 to 118 Mc/s. One, known as the reference signal has a constant phase throughout 360 degrees of aximuth but the other, which is the variable signal, has a phase which

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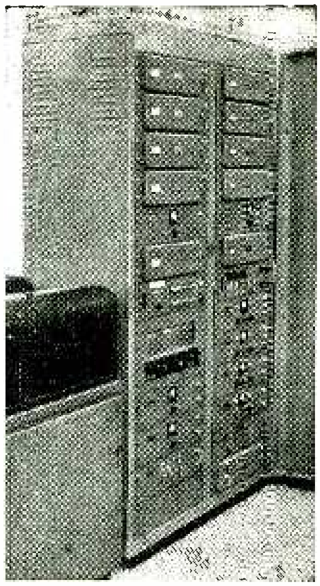
relative to the reference signal, varies with azimuth. At one point of the compass only are both signals in phase and this is generally magnetic north, or zero degrees, on the compass.

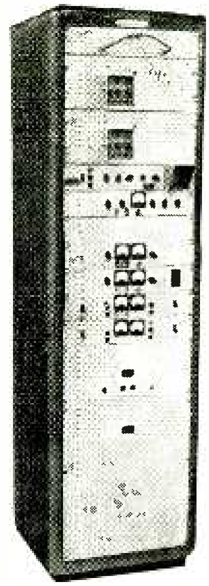
The two signals are combined in a simple phase-shifting network in the aircraft receiver and the amount of correction needed to bring both exactly in phase gives the angular displacement in relation to the datum line. This is translated into a meter reading of bearing in degrees.

Identification signals are superimposed on the omni-directional carrier and a v.h.f. radio-telephone communication service can also be included. An aircraft receiver for use with this beacon is under development by Standard Telephones and a prototype set is now available for operation in the band 108 to 118 Mc/s. It is similar in many respects to the STR12D v.h.f. equipment and operating ranges can be expected to be about the same. The accuracy of bearing provided is better than ±2 degrees and even smaller tolerances may be achieved when the set is in full production.

Last year DME (distance measuring equipment) operating in the 1,000-Mc/s band was shown. This year the frequencies in use seem to have fallen to about 200 Mc/s, but this may be only a temporary change. Be this as it may, two new lightweight DMEs are now available. Incidentally, this equipment operates on the interrogator-responder principle and is a development of the well-known Rebecca-Eureka used largely by the Royal Air Force during the recent war and subsequently in modified form by certain civil air services. The latest versions are considerably smaller and much lighter.

One equipment, shown by Marconi's and developed by their associated company Amalgamated Wireless (Australasia), uses two frequencies in the band 200-235 Mc/s and employs double pulses for air-to-ground interrogation and single pulses for the ground response. Pulse width and double pulse spacing serve as a means of coding and any one of 12 different beacons can be selected. The ground responses are displayed on a pointer meter in the aircraft as a measurement of distance in nautical miles and there are two ranges 0-10 and 0-100, also a subsidiary indicator (in the one unit) giving homing facilities in the form of a centre heading line. It is proposed to include a further indicator for orbiting a beacon and this will be adjustable for orbiting ranges of from 1 to 19 miles.



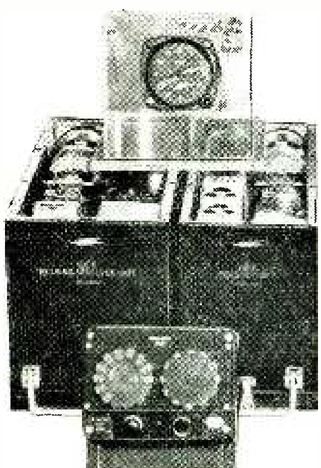


Plessey International teleprinter receiving terminal, Type PVR80 and (right) Redifon dual-diversity radio terminal teleprinter equipment.

Somewhat similar in operation and in the facilities provided in the aircraft, is the new lightweight DME developed by Murphy. It is very flexible in its method of operation and either single- or double-pulse interrogation can be provided although the equipment shown at Farnborough was the single-pulse kind. Ranges are presented on a meter scaled in nautical miles with two ranges 0-20 and 0-200 miles, respectively, but the equivalent in kilometres or other units of distance can be provided.

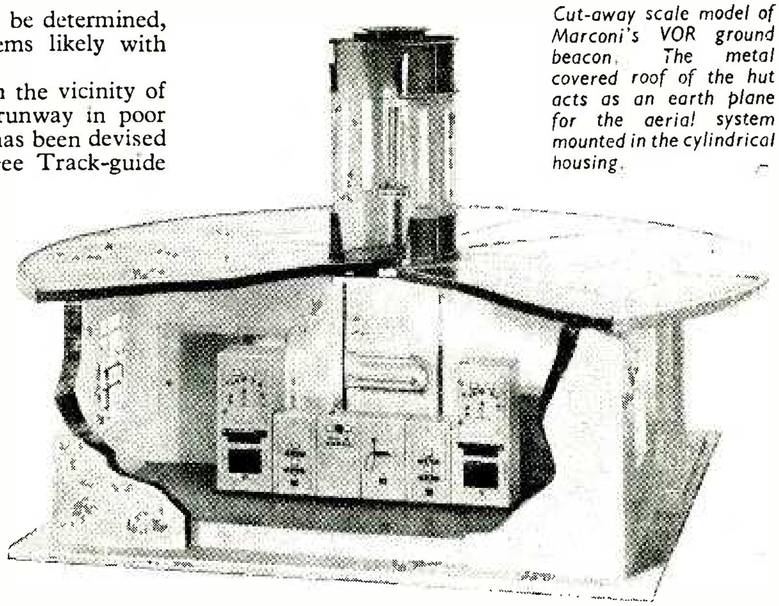
The effective range of these beacons, which are of comparatively low power for pulsed systems (about 400 watts output from the Marconi airborne set and

Standard Telephones VOR aircraft receiver and associated units and (right) Cossor Radar lightweight Mark III Gee aircraft receiver.



800 watts for the Murphy) have yet to be determined, but between 100 and 200 miles seems likely with high-flying aircraft.

A simplified form of Gee for use in the vicinity of airports as a means of locating the runway in poor visibility, or as a guide to an air lane, has been devised by Cossor Radar. Known as the Gee Track-guide System it employs only two ground stations spaced between 6 and 10 miles apart and if these are arranged to straddle the airfield, or air lane, aircraft can navigate straight in by normal Gee homing technique. This firm has also produced a new lightweight airborne Gee receiver suitable for civil and Service use in which the operation has been very considerably simplified. It is known as the Mark III Gee receiver.



Cut-away scale model of Marconi's VOR ground beacon. The metal covered roof of the hut acts as an earth plane for the aerial system mounted in the cylindrical housing.

Flying aids as distinct from navigational aids, installed and operated from the ground and requiring no action on the part of the pilot of the aircraft except to follow ground instructions, are being developed in the 3-cm (9,000 to 10,000-Mc/s) band; they are exclusively radar aids. The very high frequency enables quite narrow beams to be radiated from small and easily controlled scanners. The latest version of the Ekco Simplified Airfield Approach aid uses a small dish-shaped scanner producing a pencil-like beam, is manually controlled in the vertical plane but linked with the v.h.f. direction finder for azimuth scanning. Range and bearing are recorded and the controller can talk the aircraft down by v.h.f. radio-telephone to within visual range of the runway. Cossor showed the comprehensive installation for large airports in the form it was described in our September last issue.

The expected time of arrival at transit airports and at the destination is an essential requirement for a safe and sure air passage and also for the smooth and efficient running of the airports concerned. It is in this connection that point-to-point radio communications play their part in present-day aviation. Some equipment of this kind was shown at Farnborough and consisted of the receiving ends, or terminals as they are now generally known, of high-speed teleprinter communication systems.

Ordinary communications receivers are rarely adaptable for this purpose as the system of radio signalling employed—frequency shift keying; FSK for short—requires special receivers of high precision and extremely good frequency stability.

A radio teleprinter terminal of this kind was shown on the stand of Plessey International; it provides for FSK operation, rapid channel changing, dual-diversity reception and temperature control of all oscillator crystals.

A similar receiving assembly was seen on the Redifon stand which likewise provides for FSK, diversity reception using spaced aerials and the very good frequency stability demanded for this service.

Under certain conditions v.h.f. may provide a more convenient point-to-point service than h.f. and a case in point is a recent installation put in by Pye as part of an aerodrome radio control scheme in New Zealand, which involved communications with a remotely placed v.h.f. transmitting station. Land lines were impracticable and a multi-channel v.h.f. radio telephone designed by Pye and Ericsson Telephones in collaboration was used. One or more radio transmitters may be used and each operates six carrier-frequency sub-channels for control and operation of the remote transmitters. Frequency modulation is used for the speech channel.

There is a tendency for the radio-telephone to replace telegraphy in all communications to and from aircraft, even on the h.f. bands. It is quicker and does not require skilled telegraphists in the crew. One example of this type of equipment is the Standard Telephones ST18B 120-watt telephony transmitter which covers 2.8 to 18.1 Mc/s and provides 24 crystal-controlled remotely-selected channels. The transmitter weighs 70 lb complete and the companion receiver, the SR18B, 29 lb. Provision is made for c.w. and m.c.w. operation.

The idea of suppressed or "buried" aerials has been carried a stage further by Standard Telephones and instead of merely sinking the aerial below the surface of the aircraft the metal skin of a part or the whole is made to behave as an aerial. Developed for the ST18/SR18 equipment it consists of a capacitor-inductor unit sunk in the wing structure and tuned by remote control. It is so arranged that the metal skin of the wing is excited by this unit and behaves as

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

Burndept, Ltd., West Street, Erith, Kent.
E. K. Cole, Ltd., Southend-on-Sea, Essex.
Cossor Radar, Ltd., Highbury Grove, London, N.5.
The Decca Navigator Co., Ltd., 1-3, Brixton Road, London, S.W.9.
Ferranti, Ltd., Ferry Road, Crewe Toll, Edinburgh.
General Electric Co., Ltd., Kingsway, London, W.C.2.
Marconi's Wireless Telegraph Co., Ltd., Chelmsford, Essex.
McMichael Radio, Ltd., Wexham Road, Slough, Bucks.
M.L. Aviation Co., Ltd. White Waltham Aerodrome, Maidenhead, Berks.
Murphy Radio, Ltd., Welwyn Garden City, Herts.
Plessey International, Ltd., Ilford, Essex.
Pye, Ltd., Cambridge.
Redifon, Ltd., Broomhill Road, Wandsworth, London, S.W.18.
Salford Electrical Instruments, Ltd., Silk Street, Salford, Lancs.
Sangamo Weston, Ltd., Gt. Cambridge Road, Enfield, Middlesex.
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, Kings Cross, London, N.1.

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radiator for the transmitter, or conversely as a receiving system.

Some quite interesting lightweight v.h.f. radio telephone sets designed primarily for use in privately owned aircraft have made their appearance this year. Marconi have a very small set appropriately called the "Air-Mite"; it is crystal controlled using overtone crystals and provides also inter-communication facilities between pilot and passenger. Complete, it weighs 10 lb, gives 750 mW output on any frequency in the band 111.5 to 122.5 Mc/s.

Another lightweight set made by Burdept weighs 8 lb, consumes 55 watts only and gives 1.5 W output on a single crystal-controlled frequency in the band 117 to 128 Mc/s.

Concurrently with the Farnborough display of aircraft radio equipment was another exhibition held at Bovingdon and organized by International Aeradio. Here the equipment for use in control towers at large and small airports was shown. It consisted largely of apparatus made by well-known firms in the radio industry, the part International Aeradio play being the engineering or assembly of different types of equipment into one coherent and easily controllable unit.

Technical Training

"APART from the rapid and continuous expansion of broadcasting and television, radar and communications, the vast possibilities of radio-frequency enginering or electronics applied to industrial, medical and other uses, secure a continuity of employment well beyond the foreseeable future." In these words, the Radio Industry Council sums up in the pamphlet "Radio as a Career"* the possibilities of employment in the industry.

Under the ægis of the R.I.C. a Technical Training display, which included an information bureau, was equipped and manned throughout the Radio Show by a number of colleges. Although the number of enquiries was not large compared with those received on the "popular" stands, the display met a need which has often been expressed in these pages. It is thought, therefore, that a summary of the questions asked and the answers given might be of interest. Incidentally, it was not realized by a number of enquiring parents that *radio* courses were suitable for their sons who wanted to "take up electronics."

The majority of enquiries were from parents asking what subjects their sons, who had received their General Certificate of Education, should take when studying for their "Higher." The answer generally given was physics preparatory to studying for a degree or taking a full-time course in electronics or telecommunications at a Technical College.

Parents, who for one reason or another, did not want their sons to continue at school after 16 were told to apply to a nearby radio manufacturer for details of apprenticeship schemes, most of which come within the scope of the code laid down by the R.I.C. (see *W.W.* August, page 311). These schemes provide for a sandwich or part-time release course (usually one day a week at a technical school) at the end of which the trainee takes the ordinary National Certificate exam. in electrical engineering. This is followed by a further two years' preparation for the Higher N.C.

*Available from the R.I. Council, 59, Russell Square, London, W.C.1, and local Youth Employment Bureaux.

WIRELESS BEST-SELLERS

WHEN the foundations of *Wireless World* were laid over 40 years ago, those responsible for this journal could hardly have foreseen that publications issued by their successors would rival novels, thrillers and political scandal-books as best-sellers. In 1911 the potential readership of any kind of technical wireless book could hardly have reached 5,000 throughout the whole of the world.

Things have changed. According to a recent issue of W. H. Smith's bookstall and bookshop *Trade Circular*, W. T. Cocking's "Television Receiving Equipment" is "considerably easier to sell than any novel, including 'The Cruel Sea.'" Another *Wireless World* publication "The Williamson Amplifier" is surprisingly popular, considering its specialized appeal; a bookshop manager, writing in the *Trade Circular*, said "There is no knowing how many copies I have sold."

But the record for sales is held by our humblest booklet "Learning Morse," which during the war ran to 11 editions and over a third of a million sales. It served as a textbook for the majority of entrants to the radio communication branches of the Services, and its sales probably exceeded those of the famous non-specialist "best sellers" of the period. That in spite of the fact that it offers no easy road to the acquisition of skill and knowledge. All the stress is on correct methods, but the booklet does give one short cut to proficiency in manipulation of a morse key that had not, we believe, been described elsewhere before it appeared in the later editions.

"Learning Morse," which has just reached the 12th edition (345th thousand, with minor revisions) is issued by our Publishers at 1s (postage 1½d).

Club News

Birmingham.—The Slade Radio Society, in collaboration with the Midland Amateur Radio Society, is participating in the exhibition organized by the Sutton Coldfield and North Birmingham Model Engineering Society at Church House, High Street, Erdington, on October 2nd, 3rd and 4th, where a transmitter will be installed. The two clubs will also be uniting for a jubilee dinner at the Imperial Hotel, Birmingham, on October 25th, celebrating Slade's 25th anniversary and M.A.R.S's "coming of age." Sec.: (Slade) C. N. Smart, 110, Woolmore Road, Erdington; (M.A.R.S.) H. B. Bligh, 52, Norman Road, Birmingham, 31.

Brighton.—Dr. F. W. Alexander, of the B.B.C. Operations and Maintenance Department, will talk to members of the Brighton and District Radio Club on October 14th about studio acoustics, microphones and related problems. On October 28th a representative of Thermionic Products will demonstrate the Soundmirror tape recorder. Meetings are held at 7.30 each Tuesday at the Eagle Inn, 125. Gloucester Road, Brighton. Sec.: R. T. Parsons, 14, Carlyle Avenue, Brighton, 7.

Cleckheaton.—At the meeting of the Spen Valley and District Radio and Television Society at the Temperance Hall, Cleckheaton, at 7.30 on October 8th, J. Rose will speak on the optics of projection television. On October 5th and 16th members will visit the Holme Moss television station. The club meets on alternate Wednesdays at 7.30 at the Temperance Hall. Sec.: N. Pride, 100, Raikes Lane, Birstall, Nr. Leeds.

Leicester.—A demonstrated lecture on cinema sound-recording equipment will be given to the Leicester Radio Society by H. Turner (G8VN) at 7.30 on October 6th at the Holly Bush Hotel, Belgrave Gate, Leicester. Meetings are held on the first and third Mondays of each month at 7.30. Sec.: A. L. Milnethorpe, 3, Winster Drive, Thurmaston, Nr. Leicester.

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Commercial Broadcasting

Reactions in this Country and Experiences Overseas

"DO you approve or disapprove of the plan for television to be sponsored by advertisers?" This question was asked in a recent Gallup Poll survey of a representative cross-section of the population and the result of the investigation, quoted in the *News Chronicle*, shows that the reactions of the public fall into three groups of almost equal size—those approving of the idea, those opposed to it and those who are undecided. The *News Chronicle* states that 50 per cent of the present owners of television sets welcome the government proposals.

In view of this investigation it may be of interest to quote the opinions of Lord Simon of Wythenshaw, who during the past five years has been chairman of the B.B.C. Contributing to *The Times* recently he stressed the need for consulting the experience of other countries before embarking on the proposed scheme of introducing commercial television stations in competition with the B.B.C.

After summarizing the present situation in the United States he instances the experience, so far as sound broadcasting is concerned, of our older dominions, which is perhaps "more relevant to British conditions."

The four dominions concerned (Australia, Canada, New Zealand and South Africa) all have large areas which are expensive to cover. All of these have been forced to seek additional revenue from advertising. Australia and Canada have national services, similar to the B.B.C., and also a large number of competitive commercial stations, but both South Africa and New Zealand have a dual system of public service and commercial broadcasting under the single control of the national broadcasting organization.

In Lord Simon's opinion the example from which most can be learnt by Britain is that of South Africa. Up to 1947 South Africa had a public service monopoly of broadcasting similar to that of the B.B.C. In that year the Government decided that in order to increase the revenue it was desirable to introduce commercial broadcasting. "They wisely," says Lord Simon, "decided to send the director-general of the South African Broadcasting Corporation, Gideon Roos (a Rhodes Scholar), to investigate public service and sponsored broadcasting in the United States, Canada, Britain, Australia and New Zealand. He reported that independent commercial radio competing with a national public service system would cause very serious damage to that system, but that a commercial network under the control of the national system would provide large additional revenue and could be so managed as not to cause serious damage to public service broadcasting."

This policy, adds the writer, was adopted, and is regarded in South Africa as an outstanding success. There has been a great increase in revenue and in the total amount of listening and it is understood that standards of public service broadcasting have been maintained.

Since the publication of Lord Simon's article, the director-general of Radio Ceylon has pointed out in a letter to *The Times* that a dual system of public service and commercial broadcasting has operated under the single control of the Island's national broadcasting organization for the past two years. This, he says, has proved most successful, engendering healthy competition between the two services with a resulting improvement in the standards of presentation and programme content.

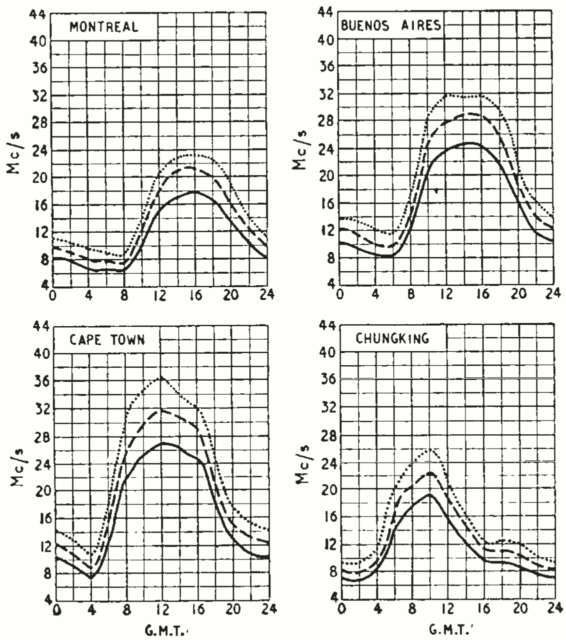
The facts quoted by Lord Simon as regards the Dominions are all concerned with sound broadcasting, because there is no experience of television. But, as he says, there is no reason to suppose that the effects of commercial broadcasting in television would be in any way different from those in sound. He adds, "while I entirely agree with the view that the South African system of mixed public service and commercial broadcasting under a single board of governors would be much less harmful than the proposal of the Charter, yet I hold strongly that the present system of public service broadcasting is by a long way the best for this country."

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.



——— FREQUENCY BELOW WHICH COMMUNICATION SHOULD BE POSSIBLE ON ALL UNDISTURBED DAYS
– – – – PREDICTED AVERAGE MAXIMUM USABLE FREQUENCY
.... FREQUENCY BELOW WHICH COMMUNICATION SHOULD BE POSSIBLE FOR 25% OF THE TOTAL TIME

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Negative-Feedback Tone Control

By P. J. BAXANDALL
B.Sc.(Eng.)

Independent Variation of Bass and Treble Without Switches

THE circuit to be described is the outcome of a prolonged investigation of tone-control circuits of the continuously-adjustable type, and provides independent control of bass and treble response by means of two potentiometers, without the need for switches to change over from "lift" to "cut." Unusual features are the wide range of control available, and the fact that a level response is obtained with both potentiometers at mid-setting. The treble-response curves are of almost constant shape, being shifted along the frequency axis when the control is operated, and there is practically no tendency for the curves to "flatten off" towards the upper limit of the audio range. The shape of the bass-response curves, though not constant, varies less than with most continuously-adjustable circuits.

The "Virtual-Earth" Concept.—The performance outlined above has been achieved by the use of a negative-feedback circuit instead of the more usual passive type of network[1,2] and it is desirable that the reader should become familiar with the "virtual-earth" concept[3] as applied to feedback amplifiers, before the operation of the tone-control circuit is considered in detail. The idea behind this concept is quite simple, and may be explained with reference to Fig. 1, in which all irrelevant details such as blocking capacitors, grid bias, etc., have been omitted, and in which V_{in} and V_{out} refer to a.c. components only. If the input resistor, R_{in}, is made equal to the feedback resistor, R_{fb}, then the circuit becomes the well-known "see-saw" or "anode-follower" phase-splitter,[4,5] and gives an output voltage which is 180 degrees out of phase with the input voltage and of slightly smaller magnitude. Now the a.c. voltage at the grid is equal to the output voltage divided by the valve gain, which may be 100 or more if the valve is a pentode, so that for many purposes the grid voltage is negligibly small in comparison with V_{in} and V_{out}. By thus neglecting the grid voltage, the following approximate relationships may be immediately deduced :—

$$I_{in} \doteqdot V_{in}/R_{in} \qquad (1)$$

$$I_{fb} \doteqdot V_{out}/R_{fb} \qquad (2)$$

where I_{in} and I_{fb} are as shown in Fig. 1.

If grid current in the valve is also negligible, which is normally the case, the application of Kirchhoff's first law (or just common sense !) to the junction of R_{in} and R_{fb} gives $I_{in} + I_{fb} = 0$, so that, from (1) and (2) :—

$$V_{in}/R_{in} + V_{out}/R_{fb} \doteqdot 0$$

$$\text{i.e., } V_{out}/V_{in} \doteqdot - R_{fb}/R_{in} \qquad (3)$$

[1] "Getting the Best from Records—Part III" by P. G. A. H. Voigt, *Wireless World*, April 1940.
[2] "Simple Tone Control Circuit" by E. J. James *Wireless World*, Feb. 1949.
[3] Section 2.5 of "Waveforms," Book 19 of Radiation Laboratory Series, published by McGraw-Hill.
[4] "The See-saw Circuit" by M. G. Scroggie, *Wireless World*, July 1945.
[5] "The Anode-Follower," by B. H. Briggs, *R.S.G.B. Bulletin*, March 1947.

When the grid voltage is neglected in this way, the grid is often called a "virtual-earth" point, and the use of this concept, though not necessary for dealing with a simple circuit such as Fig. 1, is found to be very helpful when dealing with more elaborate arrangements, and frequently gives one a far clearer physical picture of what is going on than does a straightforward mathematical analysis. The great practical value of this method of approach appears to have been first fully appreciated by Professor F. C. Williams, who also introduced the name "virtual earth."

Treble-Lift Circuit.—The basic circuit used for obtaining treble lift is shown in Fig. 2, in which the potentiometer P is made of sufficiently low resistance to ensure that the voltage at its slider, when the latter is at the middle of the element, is not appreciably affected by the current supplied to C even at the top end of the audio range. Let k be the fraction of the total potentiometer resistance lying between the slider and earth ; then the total input current, I_{in}, flowing towards the virtual earth, is $I_1 + I_2$, where I_1 is approximately V_{in}/R_{in} and I_2 is approximately $jkV_{in}\omega C$. The feedback current, I_{fb}, is approximately V_{out}/R_{fb} and the application of Kirchhoff's first law to the virtual-earth junction gives $I_1 + I_2 + I_{fb} = 0$ and hence the relationship :—

$$V_{in}/R_{in} + jkV_{in}\omega C + V_{out}/R_{fb} \doteqdot 0$$

which may be rearranged in the form :—

$$V_{out} \doteqdot - V_{in}\,(R_{fb}/R_{in} + jk\omega CR_{fb}) \qquad (4)$$

It will be seen later that in order to combine this treble-lift circuit in a satisfactory manner with the treble-cut circuit, R_{fb} should be made equal to R_{in} ; then, using R in place of these symbols, equation (4) becomes :—

$$V_{out} \doteqdot - V_{in}\,(1 + jk\omega CR) \qquad (4a)$$

The output voltage may thus be regarded as having two components, one of which is independent of frequency (for a constant value of V_{in}), whereas the other one, leading in phase by 90 degrees as indicated by the operator "j," has its magnitude proportional

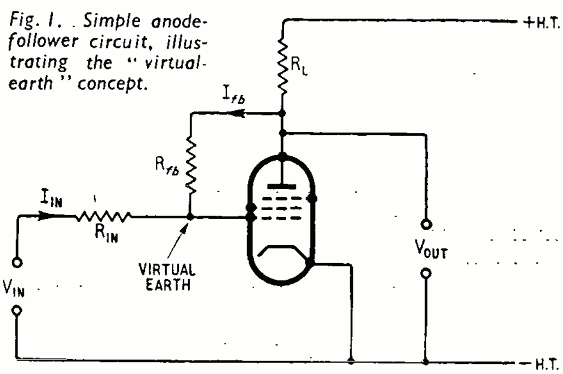

Fig. 1. Simple anode-follower circuit, illustrating the "virtual-earth" concept.

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to frequency and proportional to the potentiometer setting k.

Plotting $\left|\frac{V_{out}}{V_{in}}\right|$ in decibels, with the usual logarithmic frequency scale, as shown in Fig. 3, and letting 0 db correspond to $|V_{out}| = |V_{in}|$, the constant term in equation (4a) is represented by a horizontal dotted line through 0 db and the term proportional to frequency is represented by a line such as one of the chain-dotted sloping lines, the position of the line depending on the potentiometer setting k. The full-line curves represent the manner in which the actual total output varies, and it will be noticed that at low frequencies the total output curve is very close to the I_1 curve, whereas at high frequencies, where I_2 is much greater than I_1, the total curve almost follows the I_2 curve. The effect of varying the potentiometer setting k will be seen to be that of shifting the response curve along the frequency axis. At a point such as " P " the two output components are of equal magnitude, and because of the 90-degree phase angle between I_2 and I_1, the total output voltage will be $\sqrt{2}$ times that of each output component, or, in other words, the response will be 3db up.

Treble-Cut Circuit.—For treble cut the basic circuit is as shown in Fig. 4. The same method of analysis as was used for the treble-lift circuit gives :—

$$V_{in}/R_{in} + V_{out}/R_{fb} + jkV_{out}\omega C \doteqdot 0$$

$$\text{Hence } V_{out} \doteqdot \frac{-V_{in}}{R_{in}/R_{fb} + jk\omega CR_{in}} \quad \ldots \quad (5)$$

Making R_{fb} equal to R_{in}, as mentioned previously, and using R in place of these symbols, equation (5) becomes :—

$$V_{out} \doteqdot \frac{-V_{in}}{1 + jk\omega CR} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (5a)$$

Comparing equation (5a) with equation (4a), it will be seen that, for the treble-lift circuit, V_{out} is approximately equal to V_{in} *multiplied* by $-(1 + jk\omega CR)$, whereas for the treble-cut circuit V_{out} is approximately equal to V_{in} *divided* by $-(1 + jk\omega CR)$. Hence at any particular frequency and potentiometer setting the response of the Fig. 4 circuit will be " down" by the same number of decibels as that of Fig. 2 is " up," so that the response curves of the two circuits, for each potentiometer setting k, will be " mirror images " in the 0 db line.

Combined Treble-Control Circuit.—In order to obtain treble lift or cut with single-knob control, the two circuits just described may be combined by using a centre-tapped potentiometer, which is available commercially in carbon-track form at a price only slightly in excess of that for an ordinary potentiometer. The centre-tap is earthed, one end of the element is connected to the input terminal, the other end is connected to the valve anode (via a coupling capacitor in practice), and the slider is connected to the capacitor C. Then, when the slider is on the input side of the centre-tap, the circuit becomes that of Fig. 2, and gives treble lift, whilst moving the slider to the anode side of the centre-tap gives the Fig. 4 circuit and provides treble cut. When the slider is at the centre-tap, the capacitor C is joined between virtual earth and actual earth, but the voltage between these two points is so small, when a high-gain valve is used, that the current taken by the capacitor has a negligible effect on the frequency response within the working frequency range.

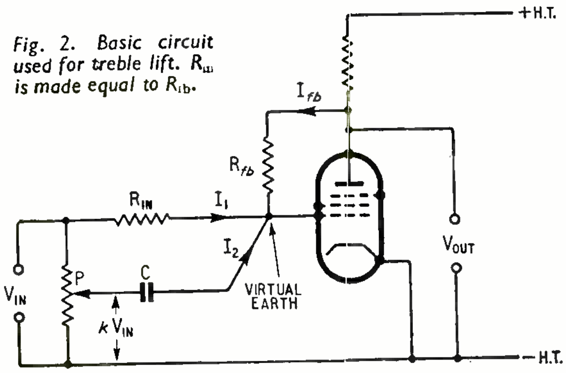


Fig. 2. Basic circuit used for treble lift. R_{in} is made equal to R_{fb}.

Bass-Control Circuit.—Fig. 5 shows the circuit

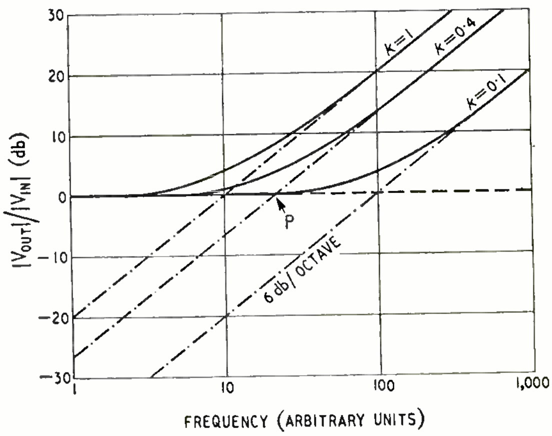


Fig. 3. Diagram showing how the Fig. 2 circuit gives a curve of constant shape but variable position. 0 db represents $V_{out} = V_{in}$. Dotted line—output due to I_1; chain dotted lines—output due to I_2, solid curves—total output.

Fig. 4. Basic circuit used for treble cut. R_{in} is made equal to R_{fb}.

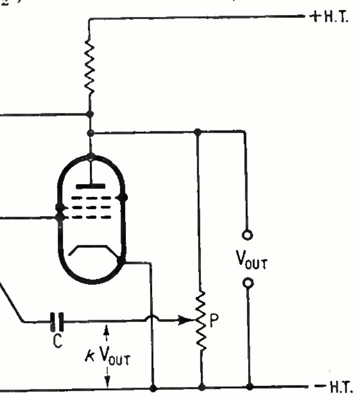
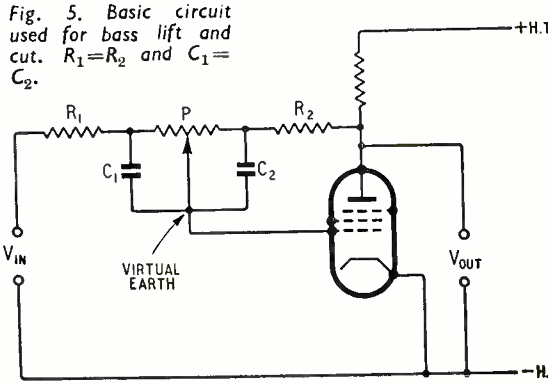


Fig. 5. Basic circuit used for bass lift and cut. $R_1 = R_2$ and $C_1 = C_2$.



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used for bass lift and cut, omitting irrelevant details as before. In order to give level response with the potentiometer at mid-setting, and to allow the circuit to be easily combined with the treble-control circuit, R_1 and C_1 are made equal to R_2 and C_2. At middle and high frequencies the potentiometer is almost "shorted out" by the low reactances of C_1 and C_2, so that the circuit becomes almost the same as Fig. 1 with $R_{in} = R_{fb}$ and a gain of approximately unity is obtained. As the frequency is lowered, the gain gradually rises or falls towards an asymptotic level determined by the potentiometer setting; and, as with the treble-control circuit, the response curves are approximately mirror images in the 0 db line for equal potentiometer displacements either side of the level-response setting.

The amount, in decibels, by which the gain of the Fig. 5 circuit departs from unity, is given approximately by :—

$$\text{Lift, in db} = 20 \log \frac{|Z_{fb}|}{|Z_{in}|} \quad .. \quad .. \quad (6)$$

where $|Z_{in}|$ and $|Z_{fb}|$ are the moduli of the impedances between input terminal and grid and between anode and grid respectively. (Note, if an impedance calculated by means of the "j" notation comes out to $R + jX$, the modulus, or magnitude, is $\sqrt{R^2 + X^2}$; see reference (6).) Equation (6) may be used to calculate the response curves, point by point, for various potentiometer settings—a straightforward though time-consuming process! The "cross-over" effect noticeable with some of the measured bass curves shown in Fig. 8 may seem surprising at first, but it is quite genuine and equation (6) gives just the same result.

Complete Tone Control.—Fig. 6 shows the final circuit evolved, which is, effectively, a combination of the treble and bass circuits described above. There is, however, one point about the relation between Fig. 6 and the previous circuits which may need some explanation. At middle and high frequencies, where C_1 and C_2 in Fig. 6 may be regarded as short-circuiting the potentiometer P_1, the relevant part of the circuit becomes as shown in Fig. 7(a). It will be seen that the three resistors R_1, R_2 and R_3 are connected in "star" between the three points A, B and C. Now it is well known that, as far as the external circuit is concerned, three resistors in "star" are exactly equivalent to three resistors, of suitably different values, connected in "delta"[7] so that Fig. 7(a) is equivalent to Fig. 7(b). In Fig. 7(b), the presence of R_c cannot appreciably affect the frequency response, because the resistance is between two points A and B both of which have a relatively low impedance to earth (point A, since the source of input voltage is assumed to be of low impedance; and point B, because it is the output terminal of an amplifier having voltage negative feedback). Hence, ignoring R_c for the above reason, Fig. 7 (b) is equivalent to a combination of the treble lift and cut circuits of Figs. 2 and 4, and therefore Fig. 7 (a) is also equivalent to this combination. The relation between star and delta networks is such that if R_1 is made equal to R_2 in Fig. 6, which is essential for giving "mirror image" lift and cut curves, then R_a and R_b in Fig. 7 (b) are each equal to $R_1 + 2R_3$. The important practical result of this reasoning is that the treble response will be 3 db up or down, at full-lift or full-cut settings respectively, at the frequency for which the reactance of C_3 in Fig. 6 is numerically equal to $R_1 + 2R_3$.

The values of the main components in Fig. 6 were decided as follows. P_1 was fixed at 1 MΩ, this being considered the highest really desirable value for a carbon potentiometer. To give about 20 db asymptotic bass lift and cut, the nearest standard value for R_1 and R_2 was 100 kΩ. A suitable compromise for C_3 was 100 pF, on the grounds that, to obtain a result in accordance with calculation, the value should be large in relation to likely wiring strays, but that too large a value would result in an undesirably low impedance being thrown across the source of V_{in}. The value of P_2 then had to be chosen so that, with the slider half way between the centre-tap and one end the effective internal resistance of the potentiometer, regarding it as a generator feeding C_3 should be not more than, say, half the reactance of C_3 at 10 kc/s. Now the reactance of 100 pF at 10 kc/s is

[6] "'j,' What it is and How to Use it," by Cathode Ray, *Wireless World*, February 1948.

[7] "Electric Circuits and Wave Filters," by A. T. Starr, p. 80 published by Pitman.

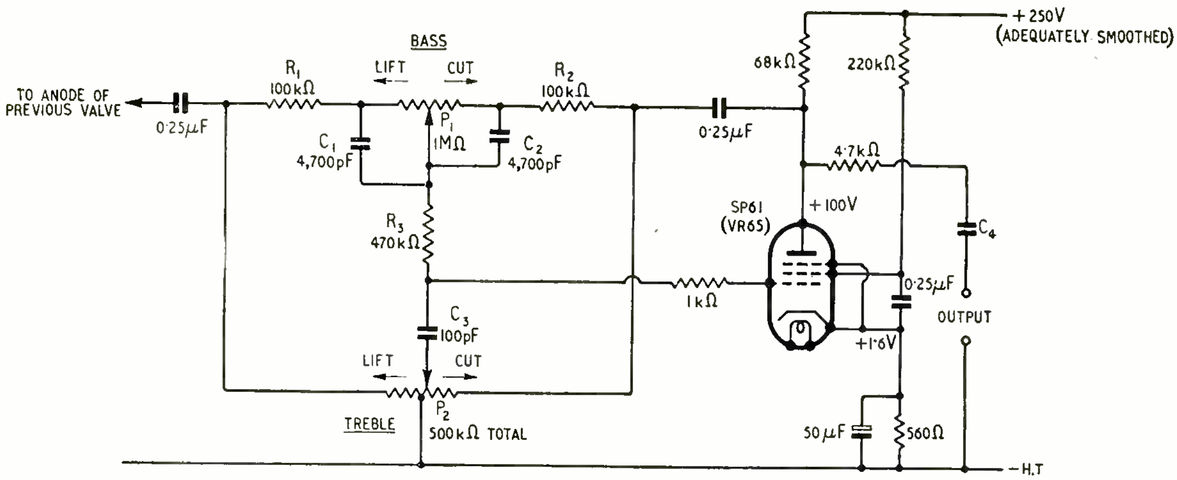

Fig. 6. The complete tone-control circuit. R_1, R_2, C_1, C_2, R_3 and C_3 should preferably be within 5 per cent of marked values. P_1 and P_2 is Dubilier Type 'C' control, 500kΩ, with fixed tapping at 50 per cent rotation. C_4 should normally be 0.05μF if following stage has 250-kΩ grid-leak.

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approximately 160 kΩ, and using a total value of 500 kΩ for P_2, each half is 250 kΩ and the internal generator resistance referred to is thus 250/4, i.e., 62.5 kΩ, which, being less than half the capacitor reactance, was regarded as satisfactory. The values of C_1 and C_2, which must always be equal, were then chosen to position the bass curves at an appropriate part of the frequency scale, and R_3 was selected to do the same for the treble curves.

A high-slope pentode valve was employed in order to obtain a high gain between grid and anode, thereby ensuring close agreement between the measured results and those given by the approximate analysis presented above. A further reason for using a high-slope pentode was that, in a feedback circuit such as this one, where the gain with feedback is almost independent of the actual valve gain, the non-linearity distortion would have been greater if a low-slope pentode or a triode had been used —an important fact which does not seem to be sufficiently widely known.

The circuit as shown in Fig. 6 will deliver an output of 4V r.m.s. without introducing more than 0.1 per cent total harmonic distortion, for any signal frequency up to 5 kc/s and at any setting of the potentiometers.

The full-line curves in Fig. 8 show the measured performance obtained with the circuit of Fig. 6. The dotted curves were obtained with the same circuit, except that the centre-tap of P_2 was disconnected from earth. The writer does not regard the dotted curves as being, for normal purposes, of so desirable a shape as the full-line curves, but since this is a very controversial matter, it may reasonably be claimed as an advantage of the circuit that the alternative curve shapes may be made available merely by adding a single-pole on-off switch.

Associated Circuits.—In conclusion, a few comments on how to incorporate the tone control in pre-amplifier circuits may be useful. These comments will be of a very general nature, because it is intended, in later articles, to describe the design of suitable pre-amplifier circuits in detail. The main points are :—

(a) The middle-frequency voltage gain of the tone-control circuit being approximately unity, it may be inserted in a pre-amplifier without appreciably altering the available gain.

(b) The output impedance of the circuit feeding the tone-control circuit should be reasonably low, preferably not more than about 10 kΩ if the tone-control elements have the values given in Fig. 6. With sources having resistive internal impedances considerably greater than 10 kΩ, R_1 in Fig. 6 may be reduced by an amount equal to the internal resistance of the source; this will give bass-lift, bass-cut and treble-cut curves as published, but less than the published treble-lift will be available.

(c) The output impedance of the tone-control circuit is quite low, because of the voltage negative feedback, and capacitance up to about 500 pF may be shunted across the output without seriously affecting the performance. This property may be employed usefully if the tone-control stage comes at the output end of the pre-amplifier, since it will then be possible to use a fairly long coaxial cable to feed the main amplifier, without the need for a cathode-follower output valve in the pre-amplifier. The feedback loop of the Fig. 6 circuit includes two phase lags at high frequencies, giving rise to a peak in the response at a frequency much above the top of the audio band; the cable capacity on the output lowers the frequency of the peak and greatly increases its magnitude, but the magnitude may be kept small by the addition of a 4.7-kΩ resistor in series with the pre-amplifier output, as shown in Fig. 6.

(d) The choice of valve is not critical, and for the less exacting kind of application quite satisfactory results may be obtained using half a double triode, e.g., 6SN7 or ECC40. The anode-to-grid capacity will cause the treble-lift curves to depart by several db from the published ones, but this is unlikely to be of much consequence in practice.

Because of the high impedance in the grid circuit, it is preferable, when very good signal-to-hum ratio is required, to use a top-grid type of valve. When the signal input level at the input to the tone-control is much less than 1 volt r.m.s., a Mullard EF37A is recommended.

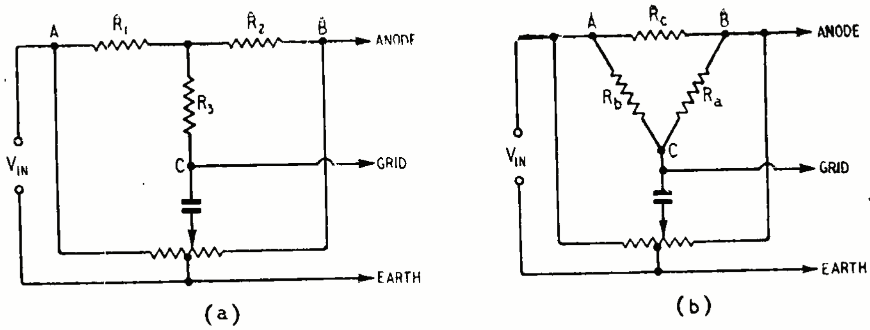

Fig. 7. (a) At middle and high frequencies, the resistors R_1, R_2, and R_3 of Fig. 6 are effectively connected in " star " ; (b) shows the equivalent " delta " network.

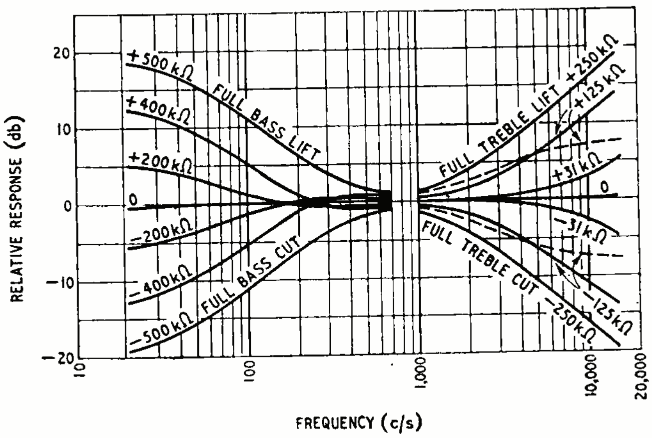

Fig. 8. Measured response curves for circuit of Fig. 6 (all components within 5 per cent of marked values ; C_4 = 0.25μF with 250-kΩ output load). Labels on curves are resistance values between potentiometer slider and centre of element. Dotted curves are with P_2 centre-tap disconnected from earth.

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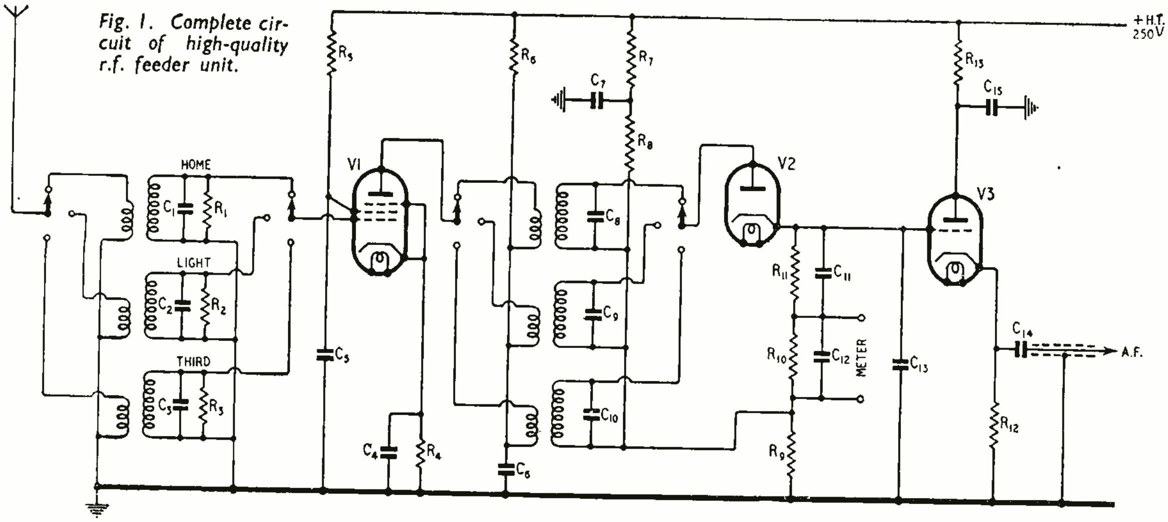

Fig. 1. Complete circuit of high-quality r.f. feeder unit.

"No Compromise" R.F. Tuner

Unit with Minimum Distortion for Use in Favourable Reception Areas

By W. WINDER, A.M.I.E.E.

AMONGST high fidelity enthusiasts the origins of distortion are generally appreciated, but most receivers, however ambitiously conceived, usually admit some compromise between conflicting factors. In the old days, when 5 per cent harmonic distortion in the output stage was thought to be acceptable, there was no future in chasing smaller traces of non-linearity in the detector and r.f. amplifier, but now that modern design has produced negative-feedback audio-frequency amplifiers of extremely low distortion, there seems to be some point in attacking these residual troubles. At any rate, the writer decided to build a "no compromise" tuner just to see what improvement could be made, and the results are sufficiently encouraging to pass along details to other enthusiasts. Compared with various r.f. tuners of conventional design the audible results are distinctly cleaner and crisper.

There is nothing special to say about frequency distortion; it is just a matter of the number and Q of the tuned circuits. In the present case, two damped circuits are used, giving good high-note response, and in the Midlands allowing interference-free reception of Third and Light programmes. London Home station is received there free from interference in the daytime, but sometimes has an audible neighbour after dark. Departure from normal practice is with the detector circuit and r.f. amplifier.

The main requirements for minimum diode detector distortion are (1) that the diode load shall be high compared with the internal resistance of the diode, (2) that the a.c./d.c. load ratio shall be as nearly as possible unity, (3) that the input r.f. voltage to the diode shall be ample—4 volts r.m.s. is usually thought to be adequate, but 6 volts is better.

With the normal circuit, where the diode feeds directly into an a.f. amplifier (and volume control), requirements (1) and (2) are mutually contradictory, and even with non-optimum values of diode load and volume control, a.c./d.c. load ratios are apt to be far from unity. Since "no compromise" was the motto in this case a different arrangement had to be found. Several methods were tried, and the final answer was to follow the diode with a directly coupled cathode follower. Except for the input capacitance of the cathode follower (about 10 pF) the a.c. load and the d.c. load are identical, thus achieving the desired unity

Component Values in Fig. 1

R_1, R_2, R_3	See text	R_8	100 kΩ
R_4	220Ω	R_9	47 kΩ
R_5	33 kΩ	R_{10}	10 kΩ
R_6	4.7 kΩ	R_{11}	220 kΩ
R_7	220 kΩ	R_{12}	10 kΩ
		R_{13}	33 kΩ
C_1, C_2, C_3	See text	C_8, C_9, C_{10}	See text
C_4	0.1μF	C_{11}	30pF
C_5	0.1μF	C_{12}	0.1μF
C_6	0.1μF	C_{13}	50pF
C_7	1.0μF	C_{14}	0.1μF
		C_{15}	1.0μF
V_1	EF50 (not critical)		
V_2	VR92, EA50, 6D1 (not critical)		
V_3	Any medium triode or r.f. pentode strapped as triode.		

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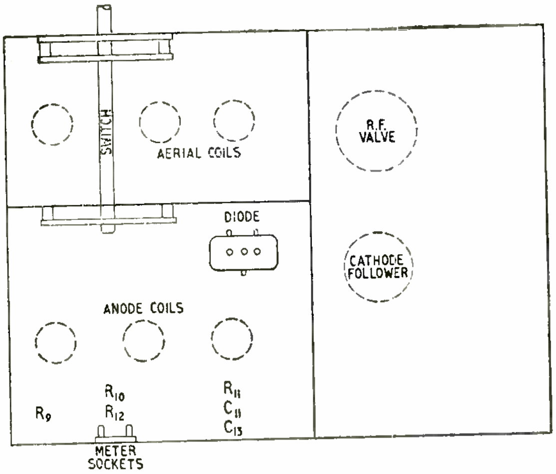


Fig. 2. Suggested layout for the principal components

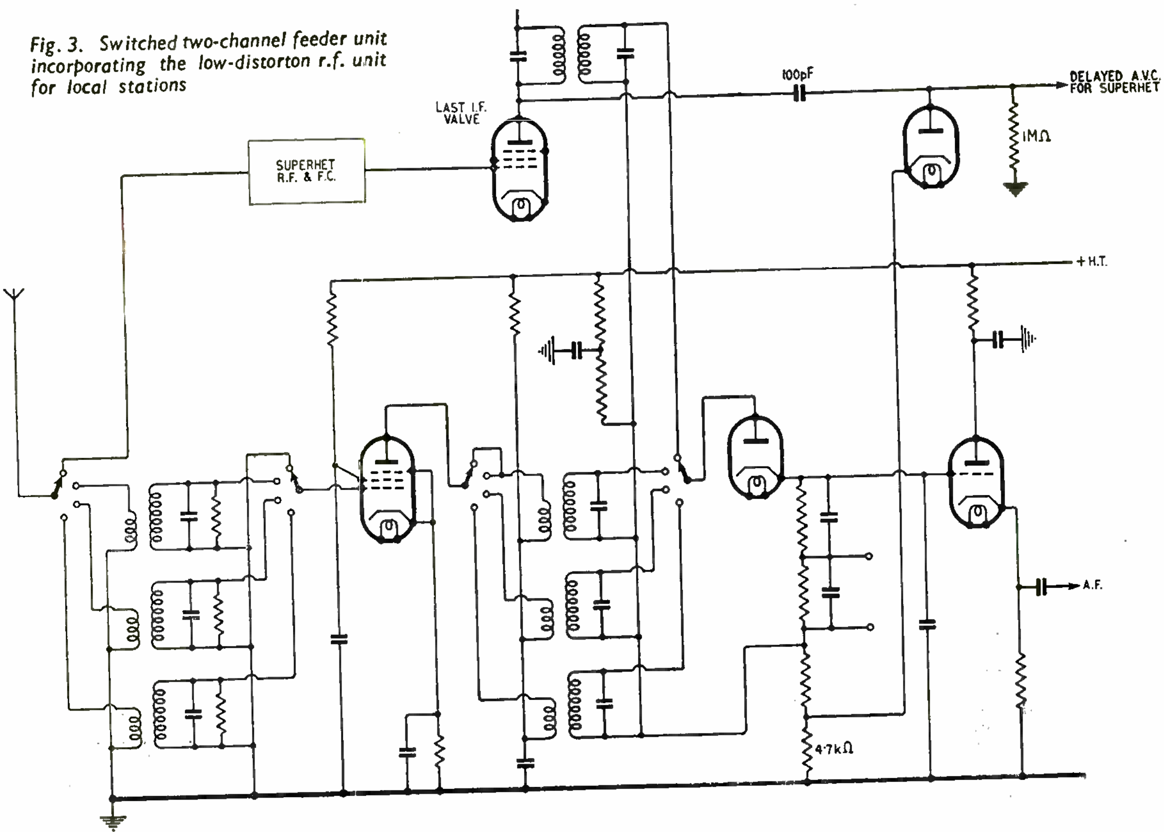
ratio without any compromise in the value of the diode load.

The cathode follower provides a secondary advantage. Normally any tuning unit will be joined to its a.f. amplifier by a longish screened lead, which, in spite of its screening, may pick up hum, and because of its screening will introduce undesirable capacitance effects. The low output impedance of the cathode follower reduces both of these troubles.

Turning to the r.f. amplifier, it is as well to remind ourselves of the variety of working conditions under which such an amplifier usually operates, varying from optimum bias with a weak signal to a condition of near cut-off on a strong local station. Here, where we are concerned at any suspicion of non-linearity, there is a case for working always at optimum bias, for it must be remembered that we are asking our r.f. amplifier to feed the detector with 6 volts r.m.s. signal. This is equivalent to 8½ volts peak, or 17 volts peak-to-peak. On 100 per cent modulation this becomes 34 volts peak-to-peak, and to provide this output with a suitable factor of safety it was decided to dispense with any form of r.f. gain control and operate the valve under conditions of maximum undistorted output. With this condition of fixed gain the input signal has to be controlled, and this is best done by a damping resistance across the tuned aerial circuit, a method which conveniently flattens the tuning where a strong signal is available and selectivity therefore least required. This calls for a separately damped aerial circuit for each wanted station. Because of this, and because the directly coupled cathode follower prevents the intervalve tuned circuit from being earthed, the use of a ganged capacitor and variable tuning has not been adopted. There is a separately tuned circuit for each station.

Fig. 1 shows the complete circuit. The values of C_1, C_2, C_3, C_8, C_9 and C_{10} are found by trial and error, and are such that they bring the tuned circuits to resonance at the required frequencies somewhere within the range of the coil inductance tuning slugs. They will depend on which stations are required in any particular district. Similarly R_1, R_2 and R_3 must also be found by trial and error. They should be so adjusted in value that in each case the diode current

Fig. 3. Switched two-channel feeder unit incorporating the low-distortion r.f. unit for local stations



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is limited to 25-30 microamps. No attempt should be made to increase the diode current beyond 40 microamps, as soon after this the EF50 shows signs of overloading. R_{10} and C_{12} have been included merely to provide a simple means of plugging in a meter for reading diode current—they contribute nothing to the circuit proper.

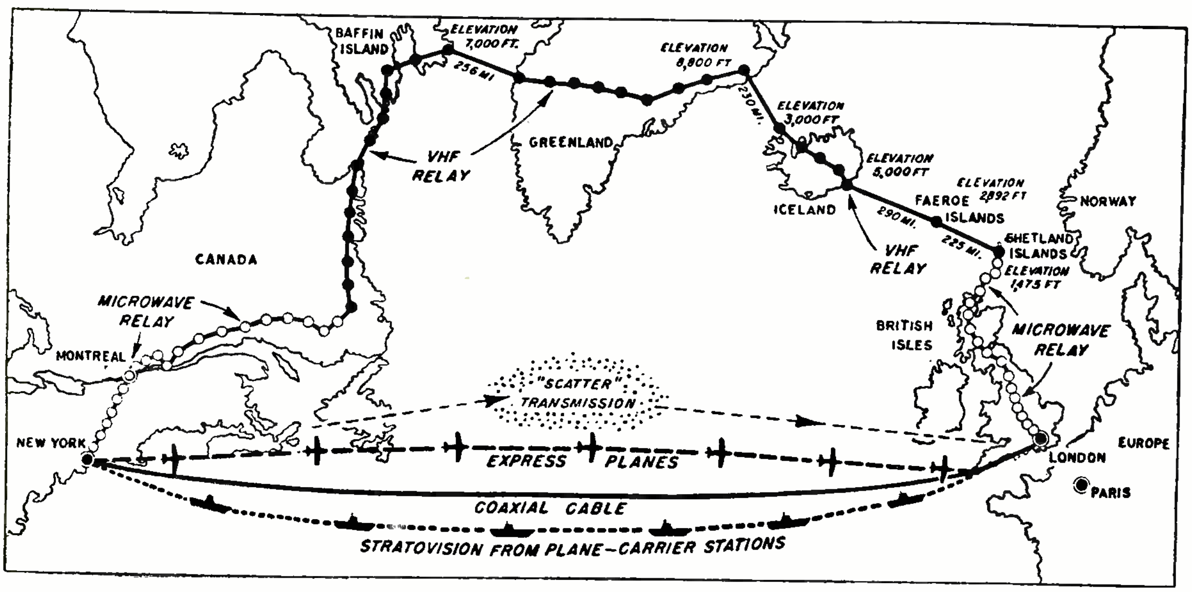
The only other points needing clarification are the direct coupling arrangements to the cathode follower. R_9 has a dual purpose. In conjunction with C_{13} it forms an r.f. filter following the detector. Also it is fed with current from the h.t. line, so that the voltage drop across it, plus the d.c. component of the rectified signal, bring the grid of the cathode follower to the correct working potential in relation to its cathode, the latter being some 35 volts above earth. The circuit is remarkably self-adjusting, and works quite happily without change of component values when fed from a 400-volt or a 250-volt h.t. line, and it will cheerfully accommodate a wide range of input signals without departing far from optimum bias. No trouble need be anticipated in the balancing arrangements due to change of valve characteristics with age. R_7 and R_8 also serve dual purposes. In total they regulate the balancing voltage across R_9. Also R_7, together with C_7, prevents 100-c/s ripple from the h.t. line from getting to the a.f. circuits. Without R_8 interposed between R_9 and C_7 the filtering effect of R_9 would be short-circuited.

As mentioned previously, no values have been given for the tuned circuits, for their frequencies will depend on choice of stations, and the damping resistances will depend on local field strengths and aerial efficiency. As a guide, in Leicester, using an indoor aerial, both Third programme and long-wave Light programme called for 100 kΩ across the aerial secondary, whilst London Home station needed no damping at all. In the same district, on a more efficient aerial, the damping resistances for Third and Light had to be reduced to 50 kΩ.

On the constructional side the chief point is to see that the aerial circuits are well screened from the anode coils (Denco "Maxi Q" coils were used in the original design). In view of the high gain of the EF50 sketchy screening will not do, and it is safest to use separately screened compartments, each containing its own switch wafer. Fig. 2 shows a satisfactory layout of the main components.

For the purely local station listener in certain localities such a tuner as described would provide all that is necessary. For listeners who do not wish to be restricted to three stations, or who live in districts which call for occasional stringent selectivity requirements, and who at the same time would like to use a high-quality tuner when occasion allowed, a two-channel receiver is suggested. One channel would be the receiver as described, and the other would be a normal superheterodyne built on the same chassis. Fig. 3 shows more or less schematically how simply this could be arranged. The station selector switch would be four-way instead of three-way, but no extra wafers would be required. The only other change in the circuit is to introduce a 4.7-kΩ resistance between R_9 and earth, to provide a delay for the a.v.c. diode.

AMERICAN IDEAS FOR TRANSATLANTIC TELEVISION



This map, taken from "Tele-Tech" for August, 1952, illustrates some of the methods which, our American contemporary urges, should be investigated in an attempt to provide, as a matter of urgency, the means for transatlantic exchanges of television programmes. The methods mentioned are: (1) Aircraft relay, with a dozen or more fast planes. (2) Radio "stratovision" relay between aircraft based on suitably spaced carriers. (3) Radio relay chain via Labrador, Greenland, Iceland and the Faeroes. (4) Submarine cable with transistor repeaters. (5) Radio "scatter transmission" (see "Wireless World," p. 273, July, 1952). (6) Miscellaneous marginal proposals, including moon reflection of radio signals.

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FURTHER NOTES ON How to Choose a Valve

Grid-Volts/Mutual-Conductance Characteristic Applied to Detectors and Modulators

By THOMAS RODDAM

IN the June, 1951, issue of this journal I discussed the way in which the single valve curve, mutual conductance as a function of grid voltage, could be used to decide which of several similar valve types should be used in an amplifier. The article contained no mention of the effect of local feedback, because it was based on the premise that overall negative feedback would be used in any amplifier that any reader is likely to design, and it did not consider any of the other applications of valves, of which the modulator is the most important. These topics will be discussed in this article.

It may be convenient to recapitulate some of the results derived in the first article, and correct some of the formulæ. We took in equation (1) the anode current I_a as a function of the steady current with no signal applied I_o, the grid voltage e_g and parameters of the valve A, B, C.

$$I_a = I_o + Ae_g + Be_g^2 + Ce_g^3 + \ldots \quad \ldots \quad (1)$$

and

$$\frac{dI_a}{de_g} = A + 2Be_g + 3Ce_g^2 + \quad \ldots \quad (2)$$

Here, then, A is the mutual conductance of the valve, and at any voltage e_g we have

$$g = g_o + 2Be_g + 3Ce_g^2 + \ldots \quad \ldots \quad \ldots \quad (3)$$

Differentiating again, $\frac{dg}{de_g} = 2B + 6Ce_g + \ldots$

Referring now to Figs. 1 and 2 in the earlier paper $2B = g/2e$ and thus $B = g/4e$.

The 2nd-harmonic distortion is thus $(g/8g_o)$ 100%. This was incorrectly given as $(g/4g_o)$. 100 per cent. in the previous article. In consequence, when third harmonic distortion is considered we will have more third than second if δ, the deviation from linearity (Fig. 2), is greater than $g/24$. Fig. 1 shows a $g_m - e_g$ characteristic which is a straight line in the working region, so that C and higher terms of e_g vanish: the $I_a - e_g$ curve is then a parabola.

The characteristic shown in Fig. 2 is quite common, especially among the small pentodes. This, in addition to producing second harmonic, which can be calculated by the expression above, also produces third harmonic, at a level $3\delta/g_o$. 100 per cent of the fundamental. For the curve shown this harmonic is phased so that it increases the peaks of the wave, while if the curve is concave downwards the third harmonic is of the right phase to make the peak value less and thus has a squaring effect.

Let us now consider what happens when we leave the cathode bias resistor of the valve unbypassed, so that there is a certain amount of negative feedback in the stage. The most useful characteristic will be a graph of mutal conductance against grid-earh voltage, which is what we should measure if to cathode resistor were built into the bulb. We des in fact, measure just this quantity on old valve which have built up a barrier layer at the cathod surface.

The effect of the bias resistor is to make $e_g = e_o - I_aR_k$ and we can rearrange this equation as:

$$(e_o - e_g) = R_k.I_a$$

Differentiating, we have

$$\frac{de_o}{dI_a} - \frac{de_g}{dI_a} = R_k \qquad \text{or} \qquad \frac{de_o}{dI_a} = \frac{de_g}{dI_a} + R_k$$

Now $\frac{de_o}{dI_a}$ is just the reciprocal of the mutual conductance with the cathode resistor in circuit, g_k, so that $\frac{1}{g_k} = \frac{1}{g_m} + R_k$

For any particular grid-cathode voltage, therefore, we obtain the effective mutual conductance by adding the cathode resistance to the reciprocal of the valve mutual conductance. In Fig. 3 this has been done, using a cathode resistance of $1/g_o$ where g_o is the mutual conductance at the working point. This is a fairly common value, and corresponds to 6 db of feedback. It will immediately be observed that the value of g is

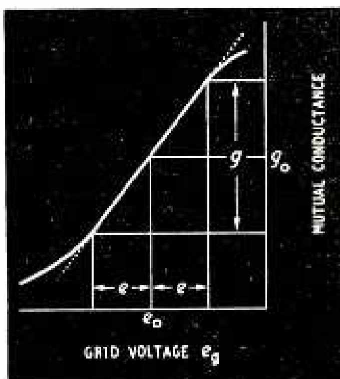

Fig. 1. The simplest type of valve g_m-e_g characteristic has a relatively long linear section.

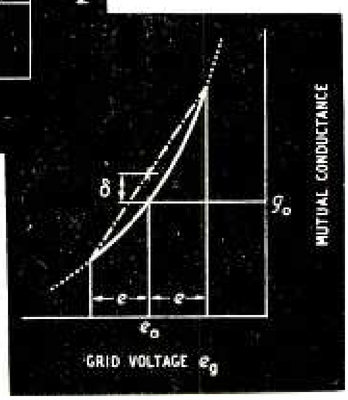

Fig. 2. A curved g_m-e_g characteristic causes third-order products proportional to the "sag," δ.

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halved for small grid excursions, so that, as we expect, the distortion is halved, but that if the valve is driven at all hard there is a substantial third harmonic component present. For the example shown, indeed, the condition $\delta > g/24$ is rapidly reached, so that there is more third harmonic than second. This third harmonic component is of the phase which tends to square the waveform, a result which will surprise no one who has examined the overload effects in an amplifier with a large amount of negative feedback.

It will not be without interest to notice how, in Fig. 4, a third-order characteristic has been straightened out to almost the straight line we associate with a second-order characteristic. A very careful examination would show the appearance here of higher-order wobbles in the curve, but the accuracy with which we can determine valve characteristics does not justify too critical an examination. The general results can be summarized by saying that a cathode resistor tends to bow the curve upwards, with particularly beneficial effects on characteristics like that of Fig. 2, and at the same time introduces harmonics of higher order.

For some special applications it is desirable to produce a very linear amplifier without using overall negative feedback. It will be clear that by adjusting the stage gains by choice of anode load, and the stage distortion by choice of cathode resistor, a fair amount of distortion balancing can be achieved, since alternate stages tend to balance the second harmonic, and "concave upwards" stages tend to balance the third harmonic from concave downwards stages.

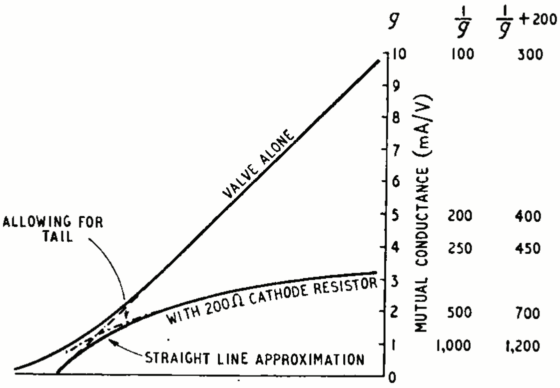

Fig. 3. The use of an unbypassed cathode resistor makes the effective mutual conductance more constant, but adds higher-order terms to the valve characteristic.

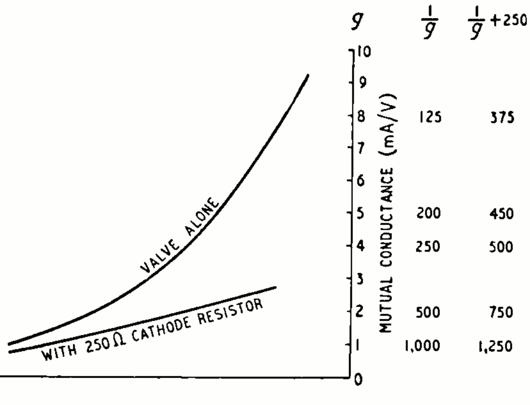

Fig. 4. A curved g_m-e_g characteristic may be straightened by a cathode resistor. This is important in modulator design.

The appearance of the third harmonic when we add negative feedback to the parabolic characteristic, or straight $g_m - e_g$ curve, which alone produces only second harmonic, is easily explained. A single frequency input between grid and cathode produces a second harmonic term at the cathode, owing to the current in the cathode resistor. We now have between grid and earth both fundamental and second harmonic: conversely, with a single frequency input between grid and earth, both fundamental and second harmonic appear between grid and cathode. The valve is not linear, and acts as a modulator, producing terms $2f \pm f$ from the terms f and $2f$ which are present between grid and cathode, and there is your third harmonic.

We must now go on to discuss the choice of a valve for use as a modulator or a detector. If we take the parabolic pentode, with a straight line $g_m - e_g$ characteristic, we have $I_a = I_o + g_m(e \sin \omega t) + \frac{Be^2}{2}(1 - \cos 2\omega t)$ where $2B = dg_m/de_g$. This equation is given at the top of p. 222 of the June 1951 issue. The direct-current component produced in the anode circuit by the application of the signal is thus

$$I_r = \tfrac{1}{2}Be^2.$$

It is not difficult to show that if signals $e_1 \sin \omega_1 t$, $e_2 \sin \omega_2 t \ldots e_n \sin \omega_n t$ are applied simultaneously to the grid, the anode current increment is

$$I_{\Sigma r} = \tfrac{1}{2}B(e_1^2 + e_2^2 + \ldots e_n^2)$$

provided that $e_1 + e_2 \ldots e_n$ does not exceed the voltage for which the linear relationship between g_m and e_g holds. The valve thus provides an anode current change proportional to the square of the r.m.s. input, and the anode current meter can be calibrated directly in true r.m.s. volts. The maximum current which can be obtained is $\frac{1}{4}ge$ and this, for a perfect valve having a cut-off at e_c volts and an average mutual conductance of g_o, will be $1/16\ g_o e_c$. The standing current, in the absence of any signal, will be $\frac{1}{4}g_o e_c$, so that we cannot have more than 25 per cent rise in anode current.

For a detector, the criterion is clearly a linear $g_m - e_g$ characteristic, and a maximum area under it. If the characteristic is not fully linear, we must compare the area under the linear portion with the area under the whole curve. Fig. 5 shows the two areas to be compared. The waste area, resulting from the tail on the characteristic, increases the standing current which must be balanced out if a meter reading from zero is to be used. The larger this standing current is for a given value of I_r the more difficult it will be to keep the system in the balanced condition. To compare two valves, therefore, we should use the ratio of these areas as an efficiency figure, and choose the valve which gives the best ratio.

An examination of the equation given above shows that the second harmonic current is equal to the rectified current, so that in a frequency doubler the change of anode current when drive is applied is a direct measure of the second harmonic term. For both these cases the use of a cathode resistor may be of assistance if a third harmonic component of the concave upwards type is present.

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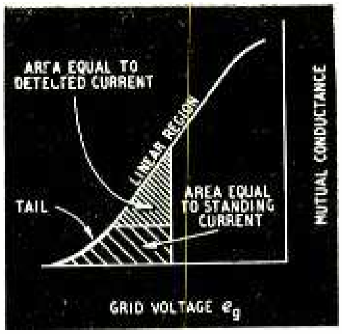

Fig. 5. The efficiency of a square-law detector depends on the length of the tail of the characteristic.

When the valve is to be used as a modulator, we shall apply a composite signal $e_1 \sin \omega_1 t + e_2 \sin \omega_2 t$ to the grid, giving $I_a = I_o + g_m(e_1 \sin \omega_1 t + e_2 \sin \omega_2 t) + B(e_1 \sin \omega_1 t + e_2 \sin \omega_2 t)^2 = I_o + g_m(e_1 \sin \omega_1 t + e_2 \sin \omega_2 t) + B(e_1^2 \sin^2 \omega_1 t + e_2^2 \sin^2 \omega_2 t) + 2Be_1e_2 \sin \omega_1 t \sin \omega_2 t$.
The first two terms in this expression can be neglected, as they are the standing current and the separately amplified signals. The third term reduces to

$\frac{B}{2}(e_1^2 + e_2^2 - [e_1^2 \cos 2\omega_1 t + e_2^2 \cos 2\omega_2 t])$ a direct

current term and a term containing the two second harmonics. The fourth term is the important modulation term: $2Be_1e_2 \sin \omega_1 t \sin \omega_2 t$

$$= Be_1e_2[\cos \overline{\omega_1 - \omega_2}t - \cos \overline{\omega_1 + \omega_2}t]$$

Each modulation term is therefore of amplitude Be_1e_2. If e_1 is very much larger than e_2 we can take $e_1 = e$ giving $I_{as} = \frac{g}{4} e_2$ where I_{as} is the anode current component of one sideband. The conversion conductance is $g/4$ which is certainly less than $g_o/8$. The term in the anode current corresponding to the signal e_2 is equal to g_oe_2 so that the filter which separates sideband from signal must deal with a signal $4g_o/g$ above the sideband. We must make g/g_o as large as possible. The anode current also contains the carrier term, $g_oe_1 = g_oe$ so that here we must filter out a term $4g_oe/g$ times as large as the wanted sideband.

Since $(e_1 + e_2)$ must not exceed e, we can see how to get maximum output. The sideband output depends on the product e_1e_2, so that a very simple manipulation reveals that maximum sideband output is obtained for $e_1 = e_2 = e/2$. We then have $I_{as} = Be^2/4 = ge/16$.

This is the maximum output which we can get from a mixer in a device like a beat-frequency oscillator, which has ample supplies of both oscillator voltages available. Each of the sources will produce an anode current component equal to $g_oe/2$ and a second harmonic term of $ge/16$. This enables us to estimate the filtering which must be provided. When operating in frequency generating equipment it is often desirable to keep the ratio of sideband to a fundamental maximum. In this case we want g/g_o to be as large as possible. Otherwise, for maximum sideband output it is the product ge, the area under the straight part of the curve, which must be large.

A radio-frequency amplifier must not introduce cross-modulation: the modulator analysis is therefore applicable, and since we are only interested in third-order products, or higher odd terms, we see that the coefficient δ is the determining one. The second-order terms $f_1 \pm f_2$ are not important, because they fall far away from the frequency range in use. In theory, then, we need not worry about the value of g, provided δ/g_o is very small. In practice it is advantageous to choose a valve with a small value of g/g_o, because any second order terms which reach a later stage will then mix under second-order conditions to provide third-order terms.

I do not propose to consider what happens to modulators with higher-order characteristics, because for almost every purpose the choice lies between using the simple parabolic characteristic, even if a cathode resistor must be added to smooth out a third-order concavity, or using a discontinuous characteristic to provide a high-order term.

Analysis of triode performance is less easily carried out in this simple way, unless the anode load is very small. If the anode load is large, a separate $g_m - e_g$ characteristic must be constructed for each possible anode load. An example is given in Fig. 6, in which the mutual conductance for an anode load of 12,500 ohms is obtained by taking the change of anode current for each 1-volt step. Travelling down the load line from $E_g = 0$ to $E_g = -1$ gives a change of 2.3 mA in the anode current, which is plotted as a mutual conductance of 2.3 mA/volt at $E_g = -0.5$. This is actually a synthetic example, which is why the excellent linearity of the $g_m - e_g$ characteristic is observed. Any triode can be studied quite critically by plotting a set of these $g_m - e_g$ characteristics with different values of anode load. The effect of cathode-resistor feedback can be analysed either by plotting the modified plate characteristics or, perhaps more easily, by operating on the $g_m - e_g$ characteristics.

This survey of the use of a single valve curve is by no means comprehensive: to make it so we should need to consider high-order terms and carry out much more complete mathematical analyses. And then we should be faced by the problem of obtaining sufficiently accurate experimental data to insert in our formulæ. The only way in which such data could be obtained would be by measurement of the high-order products in the anode current, which we could then use, in the long run, to calculate these products. All we need in practice is a knowledge of the slope and sag, g and δ, and a knowledge of how these are affected by cathode-resistor feedback. We are then in a position to understand what is happening in any particular case.

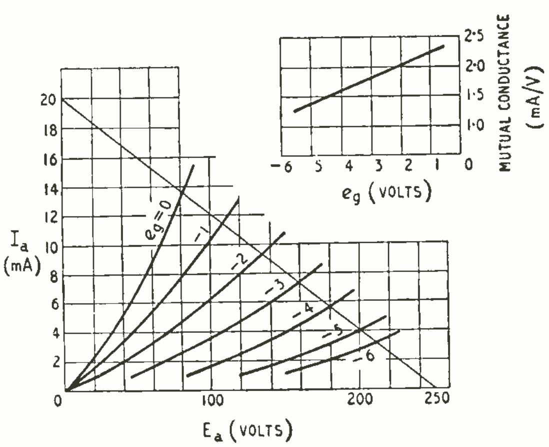

Fig. 6. For a triode it is necessary to fix the load line before plotting the g_m-e_g characteristic. This typical example shows a linear g_m-e_g characteristic for R_L=12,500 ohms.

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L/C RATIO

How Does it Affect Sharpness of Resonance?

By "CATHODE RAY"

ONE of the most familiar facts in all radio is that to tune a circuit to a certain frequency (or wavelength) you have to choose or adjust its inductance (L) and its capacitance (C) so that $LC = 1/(2\pi f_r)^2$. This formula comes in various versions, depending on which units are used and whether reckoned in terms of frequency or wavelength; but they all amount to the same thing. The quantity that decides the resonance frequency is neither L nor C alone but their product—the result of multiplying them together. And just as an acre of ground can be long and narrow or short and wide, a given frequency can be tuned to by using a lot of inductance and little capacitance, or vice versa. In other words, frequency (or wavelength) concerns only LC; in choosing the separate values of L and C the question of L/C ratio arises. If LC decides frequency, what does L/C decide?

This matter seems to be very much less generally understood than the first. Some readers have written to say that information they have on it is contradictory. In the design of stable-frequency oscillators for transmitters or signal generators, for example, some authorities recommend a high L/C ratio and others a low. It seems that both contentions can be proved.

Well, anybody who has read the discussion of oscillator circuits in the August issue may have noticed at least one possible source of such confusion. The types of stable-frequency circuits we discussed then could be regarded as either high or low L/C, according to one's point of view. But as you will probably not want me to seek refuge in a Joadian evasion, or merely refer back to the article, I will try to make the matter clear from the beginning.

Medium-Wave Tuning Circuit

You probably know already that a high L/C circuit is one having a higher impedance than a low L/C circuit; but so as not to take this too much for granted let us consider some actual figures. Take an ordinary medium-wave tuning circuit. A usual inductance for a capacitance-tuned circuit is 160μH, and employing any version of the tuning formula (or, to save time, any of the special abacs or nomograms or slide rules devised for the purpose) we find that the C required to tune it to 1 Mc/s (300 metres) is 158pF. L/C in these units is therefore 160/158 or just over 1. This could be called a medium L/C circuit. In absolute units (henries and farads) it is just over 1 million, so for convenience let's stick to μH and pF (or alternatively H and μF.)

If by taking out all the capacitance possible, leaving only stray, we managed to reduce C to 15.8pF—one tenth of the original figure—we would have to increase the inductance in the inverse proportion—ten times—making it 1,600μH to keep the resonance frequency the same. Although LC is as before, tuning to 1 Mc/s, L/C is 1,600/15.8 or just over 100; that is to say, 10^2 times as much as before. This would be a decidedly high L/C circuit. At the other extreme one could tune to the same frequency with a circuit consisting of 16μH and 1,580pF, its L/C being only about 0.01.

The condition for resonance, as we know, is that capacitive and inductive reactances are equal in magnitude. They are always opposite in sign, so at resonance they cancel out, leaving resistance as the only net impedance of the combination. But whereas all three of the pairs of reactances just specified cancel out at a frequency of 1 Mc/s, the reactances of the pairs are of course widely different. At 1 Mc/s 160μH and 158pF are both 1,000Ω; 1,600μH and 15.8pF are 10,000Ω; and 16μH and 1,580pF are 100Ω. Remembering the L/C figures in each case, we see that X is proportional to the square root of L/C. In fact, if we use absolute units we can go further and say that X is *equal* to $\sqrt{L/C}$. This is quite easy to prove. X_L, the inductive reactance $= 2\pi fL$; and X_C, the capacitive reactance $= 1/2\pi fC$. So $L = X_L/2\pi f$ and $C = 1/2\pi fX_C$. So $L/C = X_L X_C$, and as at resonance $X_L = X_C$ (call them both X) we have $L/C = X^2$ or $X = \sqrt{L/C}$.

Anybody who knows about the characteristic impedance (Z_0) of transmission lines will remember that this also $= \sqrt{L/C}$, if L and C are the inductance and capacitance of a sample of the line. This suggests impedance matching. But it may not be a very helpful suggestion to follow up, because with transmission lines one uses impedance matching with the object of obtaining a non-resonant condition, which is hardly what we're after just now. In any case, one doesn't have to know anything about transmission-line theory to see that a high L/C circuit is a high-impedance circuit, and vice versa. At a given power level, a high L/C circuit has more voltage and less current than a low L/C circuit.

But how about the practical implications of all this? What are the most important characteristics of tuned circuits, apart from frequency?

Chiefly three, I think. In those used for oscillators, frequency stability; and in those used for receiving, selectivity and voltage magnification. The first was disposed of in the August issue but as it involved one of the apparent contradictions perhaps I had better recapitulate slightly.

The frequency is determined by LC, and this is provided by an inductor and a capacitor, which are designed so that their L and C are as little affected as possible by such things as temperature, vibration, and general wear and tear. To exclude any variations due to things near them, they can be enclosed in a firmly fixed screen. But oscillations cannot be kept going in them without some connection with the outer world, usually a valve. The thing is to see that this connection doesn't ruin all the care bestowed on the tuning circuit, by introducing varying capacitance or inductance.

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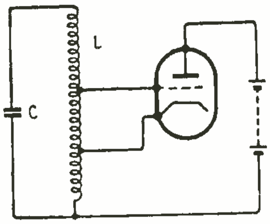

Fig. 1. When the external connections are tapped across only part of the tuned circuit, there may be difference of opinion about how the L/C ratio is reckoned.

There is bound to be some resistance associated with L and C, but the less there is the easier it is to keep oscillation going and the less the coupling need be to the maintaining valve. So, as we saw in the August article, the first rule is to have the least possible series resistance in relation to reactance; and since the ratio of reactance to resistance is commonly called Q this rule means making Q as large as possible.

Deciding the Ratio

Next we come to the L/C ratio. If this is large, C is small, so any extra capacitance brought in by the valve connection has a relatively large effect. On the other hand, if L/C is small the effect of stray inductance is accentuated. On the whole it is easier to deal with stray inductance than stray capacitance, so it is a good general rule to make L/C fairly low. If the valve system had to be connected across the whole tuned circuit, the best L/C ratio would probably be the lowest that would allow the valve to oscillate at all; but this might lead to practical difficulties with the capacitor. For constancy, low resistance, and ability to vary C, air is the best dielectric; but a variable air capacitor of much more than 500pF, or 1,000pF at most, is not usually very convenient. So for most purposes one uses a medium L/C and taps the valve across as little of the tuned circuit as possible, as in Fig. 1. The part of the tuned circuit across which it is not tapped then includes both inductance and capacitance, and may even include most of them that there is; so much so that it looks to some people like a series-tuned circuit. If so, they may be surprised to see that the supposed L/C ratio in a very constant-frequency oscillator is extremely high. A typical quartz crystal for 1 Mc/s might have L = 840,000μH and C = 0.03pF, making L/C = 28,200,000 compared with 1 for a typical receiver circuit! But if you regard the tuned circuit as the one that is in resonance, you will think of Fig. 1 as a parallel-tuned circuit, L in the formula being the portion of inductance across which the valve is connected and C the rest of the inductance in series with the tuning capacitance. The latter combination must work sufficiently off resonance to make its net reactance equal to the right C to tune L. Since L is very small, this C equivalent must be quite large, and the L/C ratio (in this view) is small. In the crystal-controlled and so-called Clapp circuits, the valve is tapped down on the capacitance side, and again the parallel L/C ratio is small, although the L/C of the series portion by itself (especially if it consists of a crystal) is extremely large. You see now how easy it is to get at cross purposes about L/C ratio!

But since this matter of oscillator circuits was gone into at length in the August issue, the main subject this time ought to be selector circuits, such as one uses in receivers. The need to avoid undesired detuning applies to these also, of course; but there is the additional need to obtain a desired standard of selectivity. And about this too there is sometimes confusion of thought.

Here is one argument I have heard about our parallel LC tuning circuit. Since L and C are in parallel, it is appropriate to represent them by a susceptance sketch, as explained three months ago. (Susceptance, you remember, is 1/X.) Adding together the separate susceptances of L and C gives the susceptance of their parallel combination. If the L/C ratio is large, the reactances are large and the susceptances therefore small, which is represented in the sketch, Fig. 2(a), by drawing the curves close to the frequency axis. A lower L/C circuit is represented by the steeper curves in Fig. 2(b). In both cases the susceptance at f_r, the resonance frequency, is zero; which means that the reactance is infinitely large, so provides no path for current. So far everything is perfectly sound. But the argument then runs off the rails by saying that because the curves show that the susceptance of a low L/C circuit changes more steeply with frequency than that of the high L/C circuit, the low L/C circuit must have a sharper resonance peak. That is to say, the lower L/C the greater the selectivity. Every parallel LC circuit is also, from another point of view, a series LC circuit; and if one were to sketch the *reactance* curves for the same circuit from the series point of view, and use the same argument, one would arrive at the conclusion that to sharpen the resonance peak one should *increase* L/C! Now a sharp series and a sharp parallel resonance go together, so clearly there is something wrong with the argument.

You have probably spotted it already. It is forgetting that a reactance or susceptance sketch, useful though it is when treated intelligently, is only part of the whole picture. When considering selectivity the missing part, which is resistance, just mustn't be ignored. As I explained in the July issue, a reactance sketch is just a plan view of a three-dimensional curve, which stands above the paper at a distance representing the resistance of the circuit; a susceptance sketch similarly fails to show its third dimension—conductance. At frequencies far from resonance the resistance (or conductance) of any reasonably

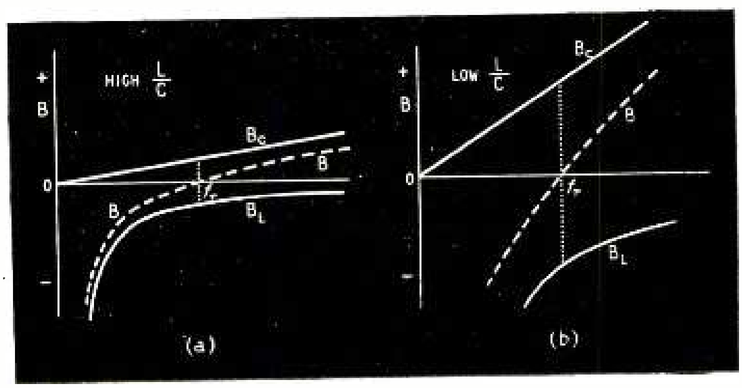

Fig. 2. Susceptance sketches for (a) high-L/C and (b) low-L/C tuned circuits. Which would one say was the more selective?

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low-loss tuning circuit is so much smaller than the reactance (or susceptance) as to be unimportant; but at resonance, where reactance (or susceptance) is zero, resistance (or conductance) is all-important. If the X curve of a series circuit, for example, stood high off the paper, meaning that the resistance was large, the impedance (represented by the distance from the curve to the f axis) would change quite slowly with frequency, regardless of what X was doing.

Effect on Selectivity

Again, attempts are sometimes made to demonstrate the influence of L/C ratio on selectivity by quoting various formulae. And again it is very easy to arrive at conflicting conclusions. It is advisable, to say the least, to begin by agreeing on what is meant by selectivity. Part of the confusion, I suspect, is due to not doing this. If one is using coupled tuned circuits, the question is complicated by the degree of coupling; but just now we are considering selectivity in terms of the simple tuned circuit, in which the variables are L, C, R, and f. The proportions and position of the resonance curve can be varied, but not its basic shape. So all that one needs to know is the width of the resonance curve at an agreed distance down its slopes. Calculation is simplified if it is agreed to measure the width where the power due to a given series input voltage is reduced to half of what it is at resonance. This level is 3db down, and is the same as 70.7% (= $1/\sqrt{2}$) of peak voltage or current, as in Fig. 3. Curves for any number of tuned circuits in successive stages of amplification (provided that there is negligible direct coupling between the circuits) can be derived by adding their individual db levels relative to peak.

Even when all this has been agreed, there are still two different ways of reckoning the width. Which to use depends on what the tuning is wanted for. Since the vertical dimension—the response—is reckoned relative to the response at resonance, the natural thing is to reckon width in frequency relative to the frequency at resonance. In Fig. 3 this would be $(f_2-f_1)/f_r$. Since this represents bluntness of resonance, sharpness of resonance would naturally be $f_r/(f_2-f_1)$. Its relationship to the circuit is delightfully simple; it depends on Q and on nothing else—$f_r/(f_2-f_1)$ = Q. So this way of reckoning selectivity by sharpness of resonance ties up very nicely with sensitivity, or circuit magnification, which is also equal to Q (subject to the reservations I mentioned in the July, 1949, issue).

And for some exceptional purposes it is the natural thing to want. But not in receivers. Receivers are normally required to accept a specified frequency band and keep out all else. This bandwidth is decided by the modulation, and the carrier frequency doesn't come into it at all. Assuming that voice frequencies up to 5kc/s are wanted, and a double-sideband a.m. system is in use, the requirement is an acceptance band of 10kc/s, regardless of whether it is centred on Droitwich (f_r=200kc/s) or London Home Service ($f_r \times$908kc/s) or London television sound (f_r=41,500kc/s). So for purposes of receiver design the appropriate way to reckon sharpness of resonance is simply $1/(f_2-f_1)$, which is the reciprocal of bandwidth at the half-power level. Rearranging the "natural" formula accordingly, it is equal to Q/f_r.

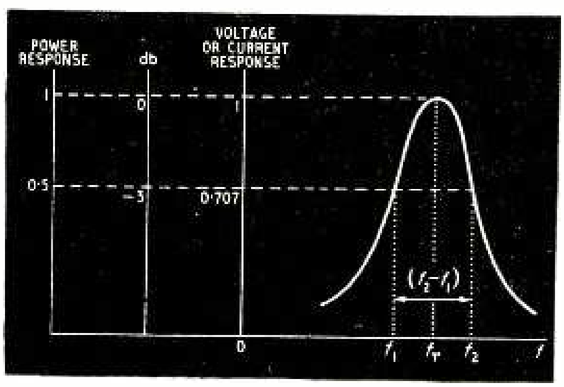

Fig. 3. Standard method of reckoning sharpness of resonance.

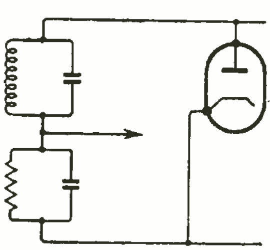

Fig. 4. Typical environment of a tuned circuit, loaded by a diode detector, which is equivalent to a certain resistance.

Confusion over Q

Now if two people are arguing about tuning circuits, and one takes for granted the natural definition of sharpness of resonance, which makes it equal to Q, and the other, more practically minded, reckons it is Q/f_r, or more probably one of its equivalents that doesn't reveal the discrepancy so plainly, it is not surprising if they get at loggerheads.

It is these equivalents that usually cause the muddle, because there are quite a lot of them. Let us start from Q/f_r. Q itself contains f_r, because it is X_r/r, where X_r is the reactance of either L or C at resonance, and r is the resistance which, placed in series with L and C, would cause as much power loss as actually takes place. Since $X_r=2\pi f_r L$, then $Q=2\pi f_r L/r$, and $Q/f_r=2\pi L/r$. Of this, 2π is just a simple constant, so for comparative purposes could be left off, giving a measure of sharpness in units 6.28 times bigger. (The larger the units used for specifying a measurement the smaller the number of those units. A distance equal to 3 in inches is only 0.25 in feet.)

The rearrangement just made brings L into the picture; can C be made to appear at the same time? Yes, it can. $X_r = X_L = X_C = \sqrt{X_L X_C}$; and substituting the full details of X_L and X_C we get $\sqrt{L/C}$, which is just what we have been looking for. So our sharpness of resonance, Q/f_r (let us call it S for short) is equal to $\frac{1}{f_r r}\sqrt{\frac{L}{C}}$. In other words, it looks as if it is proportional to the square root of the L/C ratio, and a high L/C ratio should be chosen for getting high selectivity.

But alas! If we approach the same point from a different direction, using a parallel resistance R to represent the cause of all power loss in the circuit (as it is quite legitimate to do) the appropriate expression for Q is R/X, and S is therefore $R/f_r X$. Perform-

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ng exactly the same operation on X as before we get the result $S = \frac{R}{f_r} \sqrt{\frac{C}{L}}$, which makes it look as if what one must do to obtain sharp tuning is aim for *low* L/C. So even starting from the same definition of sharpness, there seems to be no guarantee of results that make sense! Which of these apparently contradictory instructions is one to accept?

Well, of course, the contradiction is only apparent. The mistake is in assuming that r or R will remain calmly constant while we are playing about with L/C. In practice nearly all the power loss is associated with the coil. So when, following the first equation, we increase L, the series resistance goes up too, and in doing so more or less neutralizes the advantage of the higher L/C ratio. Or if we choose the second equation and reduce L, R falls too, and again works contrariwise. So in spite of appearances the two equations actually come to precisely the same thing.

It is nearly closing time and we seem to be as far away as ever from an answer to the question, how does L/C ratio affect sharpness of resonance? Not to keep anyone in suspense any longer, I will give my answer for what it is worth, which is that any effect of the L/C ratio on sharpness of tuning is purely coincidental. There is no simple proof of this. S, you remember $= Q/f_r$. Now f_r doesn't involve L/C; as we said at the start, f_r depends only on LC, and L/C can be varied quite independently. So, with either method of reckoning sharpness of resonance, all depends on Q. The Q of any normal tuned circuit really means the Q of the coil, for the capacitor losses ought to be negligible in comparison. How does Q vary with L? Since $Q = 2\pi f L/r$, it might seem that it is directly proportional to L; but we are not likely to be caught by that one again. What does r do?

That is really the crux of the whole matter, and the difficult thing to prove, because r, the quantity that represents the cause of the total coil losses, depends on dozens of things—every dimension of the coil, every material used in its construction, the number of turns, their gauge and spacing, and so on. This subject has been investigated for many years, and a fairly recent specialist book on it (Dr. V. G. Welsby's "Theory and Design of Inductance Coils") confirms that if you vary only the inductance o a given type of coil—by varying the number and gauge of turns but keeping everything else as much as possible the same—it makes no difference to Q. In practice, Q might be a little more or a little less, depending on the precise details of construction; hence my conclusion that any effect on sharpness of resonance of varying the L/C ratio is purely coincidental.

Just to make sure there is no misunderstanding, however, I must point out that this conclusion takes no account of special circumstances—in particular any external loading of the tuned circuit. Suppose this loading takes the form of a resistance in parallel, as in Fig. 4 where the voltage developed across the tuned circuit is applied to a diode detector, which might be equivalent to a resistance of, say, 100kΩ. Suppose the tuned circuit is our medium-L/C 1-Mc/s example, with its X_r of 1kΩ. If its Q were 100, then its equivalent parallel resistance R ("dynamic resistance") at resonance, $= QX_r$, would be 100kΩ; and the 100-kΩ loading across it would reduce the net parallel resistance to 50kΩ and the overall Q would be 50. Substituting the high-L/C circuit, with its 10-kΩ reactance, we would have an unloaded dynamic resistance of 100 × 10 = 1,000kΩ; and obviously this would be far more heavily loaded by the 100-kΩ, detector. The resistance of circuit and load in parallel would be 91kΩ, and with X_r = 10kΩ the overall Q would be 91/10 = only 9.1. The low-L/C circuit would be less heavily loaded, the overall Q being 91. Here they all are in a table, with reactances and resistances in kΩ:

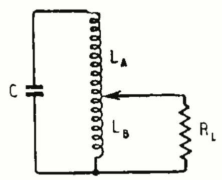

Fig. 5. In the favoured method of reckoning L/C ratio, L is the part across which the load resistance or other external circuit is connected; in this case L_B. If the load is tapped on the C side, the same principle applies there.

L/C (μH/pF)	X_r	R	R′	Q′
1	1	100	50	50
100	10	1,000	91	9.1
0.01	0.1	10	9.1	91

X_r = reactance of L (or C) at the resonance frequency, 1 Mc/s
R = dynamic resistance of tuned circuit alone = QX_r
Q = Q of tuned circuit alone = 100
R′ = dynamic resistance of tuned circuit in parallel with 100-kΩ load.
Q′ = Q of tuned circuit loaded by 100kΩ in parallel = R'/X_r

Similarly it can be shown that a load resistance in *series* with the tuned circuit is related in the opposite way, reducing the Q and hence the sharpness of resonance more when L/C is low than when it is high. In practice a tuned circuit is almost sure to be loaded somehow or other if it is to be of any use, so choice of L/C ratio is really bound up with that. Most often, tuned circuits are loaded in parallel. So if one is aiming at high selectivity, in combination with high frequency stability, the choice will be low L/C; it being understood that this ratio is reckoned on a parallel basis. For example, in Fig. 5, L would not be the whole coil, but only the part L_B across which the load is connected; and C would not be just what is marked C, but the net reactance of C and L_A at the working frequency. It could be reckoned most easily as the capacitance needed to tune L_B to resonance.

From this it might seem that there is no limit to the desirability of low L/C. But of course there is, because although a given *voltage* injected in series with a tuned circuit of a given Q is magnified to the same extent however low L/C may be, one is generally given a lim ted *power*, and the maximum output is obtained when impedances are properly matched. We found, earlier on, that $Q = R\sqrt{C/L}$, so $R = Q\sqrt{L/C}$, and if Q is more or less constant it is clear that R, the dynamic resistance, can be adjusted by L/C. Choice of L/C ratio, then, has to be a compromise between the often conflicting requirements of sensitivity, selectivity, and frequency stability, and depends on how power is brought in and taken out. So although I hope I have managed to make the matter clearer, you see that there is no simple golden rule covering all situations, enabling one to dodge all the hard work. Life is like that.

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WORLD OF WIRELESS

Speaker Tax Clarified ♦ A.M./F.M. Schedule ♦ N. American News

P.T. on Loudspeakers

AMPLIFICATION of the order imposing Purchase Tax of 66⅔ per cent on loudspeakers (see p. 362 of last issue) has been issued by the Customs and Excise Office as a result of consultations with the radio industry. Incidentally, there have been strong criticisms of the imposition of this tax without prior consultation with the industry.

The announcement states that "loudspeakers of other than the cone type, e.g., pressure units, are not chargeable with Purchase Tax. . . . All separately supplied cone-type loudspeakers (whether mounted or not) of sizes up to and including twelve inches nominal diameter are subject to the tax, regardless of the purpose for which they are supplied."

The tax does not apply to loudspeakers supplied as parts of a complete public-address or communication system. The liability to tax of replacement or additional loudspeakers for such installations will be determined in accordance with the decision quoted above.

It is pointed out that a loudspeaker, of whatever type or size, incorporated in a broadcast receiver is chargeable with tax as part of the complete set.

Wrotham Schedule

SLIGHT changes were recently made in the schedule of experimental transmissions from the B.B.C's a.m./f.m. station at Wrotham in order to permit the inclusion of the Promenade Concerts. From 1st October, however, the following schedule will be used for the transmissions which are radiated simultaneously on 91.4 Mc/s (f.m.) and 93.8 Mc/s (a.m.).

11.0-noon, 1.0-2.0, 2.30-4.30	Mon.-Thurs., Light Programme.
6.0-close down	Sun., Mon., Tues., and Thurs., Third Programme.
	Wed. and Sat., Home Service.

It is emphasized by the B.B.C. that the transmissions are experimental and times may therefore be varied.

Brit. I.R.E. Premiums

THE premier award of the Brit. I.R.E.—the Clerk Maxwell Premium (20 gns) for the most outstanding paper published in the Institution's *Journal* during the year—will be presented at the Annual General Meeting to Dr. H. Paul Williams (formerly with Cossors and now with Fairey Aviation Co.) for his paper "Subterranean Communication by Electric Waves."

The recipients of other awards and the titles of the papers for which they are made are: Heinrich Hertz Premium (20 gns) to R. E. Spencer (E.M.I. Engineering Development) for "The Detection of Pulse Signals Near the Noise Threshold"; Louis Sterling Premium (15 gns) to Emlyn Jones (Mullard Research Laboratory) for "Scanning and E.H.T. Circuits for Wide-Angle Picture Tubes"; Leslie McMichael Premium (10 gns) to R. G. Kitchenn (Postmaster-General's Dept., Australia) for "An 8-Channel Transmitter for an Experimental Carrier Wire-Broadcasting System"; Brabazon Premium (15 gns) to G. E. Roberts (Decca Navigator) for "The Design and Development of the Decca Flight Log"; and Marconi Premium (10 gns) to E. G. Rowe (S.T.C., Brimar Valve Division) for "The Technique of Trustworthy Valves." The Dr. Norman Partridge Memorial Award and the 1951 Students' Premium have not been awarded. Graduateship Examination prizes have been awarded to G. R. Beswick (Birmetals, Ltd.) and C. J. White (B.B.C., Daventry).

Show News

ALTHOUGH the attendance at Earls Court did not reach the record of the first post-war show at Olympia (443,433), the final figure of 289,899 was some 57,000 in excess of last year's total.

It is understood that the Radio Industry Council proposes to hold next year's National Radio Exhibition—the twentieth—at Earls Court on approximately the same dates as this year—early September.

British P.A. in Canada

THE responsibility of designing and installing a new speech reinforcement system for the Canadian House of Commons in Ottawa has been entrusted to Tannoy Products, whose experience in equipping both Houses of Parliament in this country, and the Indian Legislative Assembly, New Delhi, must be unique.

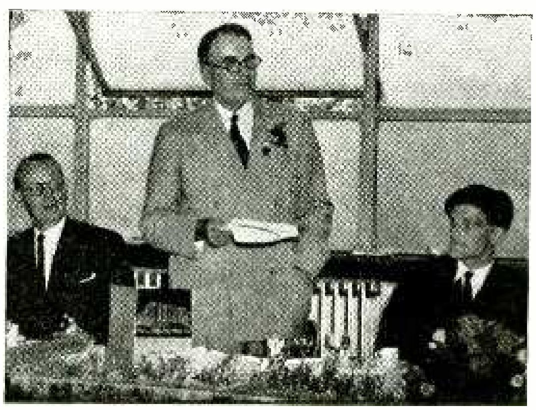
The basic principle of dividing the House into zones, each equipped with a directional microphone and the automatic muting of adjacent low-level reinforcing loudspeakers by a relay system, has been adopted, and the installation calls for no fewer than 23 microphones and 550 loudspeaker units, the latter being installed between the double desks. A well-thought-out system of control and monitoring is under the hands of a strategically placed operator.

Initial installation and operation of the equipment will be carried out by Tannoy technicians; subsequent operation and maintenance will be undertaken by Cossor (Canada), Ltd.

N. American Convention

A RECIPROCAL radio convention between Canada and the United States, which came into effect on August 12th, permits the operation of radio equipment by citizens of one country when in the other.

It is no longer necessary for operators of business-radio gear, or those with mobile radio-telephones for linking with the public telephone service, to cease using their equipment after crossing the frontier. Holders of amateur radio licences may also operate their equipment in their cars over the border or when temporarily in the neighbouring country. Licences for air radio operators are also valid in both countries.



ADMIRAL DORLING, R.I.C. Director, addressing the gathering at Earls Court when J. R Acton (right) was presented with the first R I.C. Technical Writing Premium by A. R. W. Low, Parliamentary Secretary to the Ministry of Supply (left) for his article "The Single-Pulse Dekatron" published in "Electronic Engineering."

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PERSONALITIES

Lord Hankey has retired from the chairmanship of the Technical Personnel Committee of the Ministry of Labour and National Service. In 1940, when Chancellor of the Duchy of Lancaster, he became responsible for the supply of radar and radio personnel and in 1941 he was appointed chairman of the Technical Personnel Committee, which was given the task of organizing the scientific man-power of the country. In October last year the committee was reconstituted with wider terms of reference than in wartime and Lord Hankey consented to be chairman during the initial stages of its works. He is succeeded by Sir George Gayter.

Sir Edward Appleton, F.R.S., has been nominated president of the British Association for the Advancement of Science for 1953. This was announced at the annual assembly of the Association in Belfast. Next year's annual meeting will be held in Liverpool. Sir Edward, who has been Principal and Vice-Chancellor of Edinburgh University for the past four years, was for the previous ten years administrative head of D.S.I.R.

L. H. Bedford, O.B.E., M.A. (Cantab.), B.Sc., is among five past students of the City & Guilds College who have had the Fellowship of the City & Guilds of London Institute conferred upon them "in recognition of their distinguished services and outstanding contributions to the advancement of the industry in which they are engaged." He started his career with Standard Telephones & Cables and in 1931 joined A. C. Cossor, Ltd., where he was closely associated with the development of radar. In 1947 he joined Marconi's, where he is chief television engineer.

H. W. Bowen, O.B.E., who from 1946 until recently was managing director of E.M.I. Factories, Ltd., has become managing director of Britannic Electric Cable & Construction Company—one of the two operating subsidiary companies of Radio & Television Trust, Ltd. The other operating company is Airmec Laboratories, Ltd.

T. E. Goldup, M.I.E.E., who, as announced last month, has been elected a vice-president of the I.E.E., succeeds Professor Willis Jackson as chairman of the Board of Governors of the Ministry of Supply's School of Electronics at Malvern, Worcs, of which he has been a governor since 1949. He is also a governor of the Wandsworth Technical College and a member of the advisory committee of the Norwood Technical College. Mr. Goldup is a director of Mullard, Ltd., which he joined in 1923.

T. R. B. Sanders, C.B., who during his seven years in the Ministry of Supply (where he held a number of key posts) was concerned with the technical development of a wide range of Service equipment, has been appointed engineering adviser to the British Standards Institution.

J. Foster Veevers, M.I.E.E., has been appointed general manager of Plessey's Swindon Works, where, in addition to the large-scale production of repetition parts, electrolytic capacitors, volume controls and other radio components are manufactured. Prior to joining the Plessey Company, he was with the General Electric Co. as manager of the Stockport works of Salford Electrical Instruments, Ltd.

Major H. MacCallum, B.Sc., first Marconiphone manager, was presented with a television set by the company during the Earls Court Show. He was responsible for the production of the first valve receivers made by Marconiphone and was associated with the arrangements for the first broadcast from 2LO London.

IN BRIEF

Licence Figures.—At the end of July the number of broadcast receiving licences in the U.K. had reached 12,777,690, including 1,564,254 for television and 151,765 for car receivers. During the month television licences increased by 25,703.

COMPARISONS. At the presentation to Major MacCallum (right) comparisons were drawn between the price of the first Marconiphone "Ideal Home" loudspeaker sets—which had four valves, 25 components and 20 soldered joints—and a 14-valve (+ c.r.t.) television receiver, with over 200 components and some 500 soldered joints. The 1922 set cost £51 18s 0d (no P.T.), while the Marconiphone VT59DA television set costs £49 15s 0d (plus £22 13s 2d P.T.)

OUR AUTHORS

Peter J. Baxandall, the author of the article "Negative-Feedback Tone Control" in this issue, is a senior scientific officer in the Physics Department at T.R.E. Until 1944, when he went to Malvern, he was at Cardiff Technical College training Fleet Air Arm radio mechanics. He was previously a student at the College, where in 1942 he obtained his external London B.Sc.(Eng.) degree with second-class honours. He worked for a short while at T.R.E. with Prof. F. C. Williams. His interest in sound reproduction is purely as a hobby and the circuit arrangement of the tone control described in this issue was awarded the *Wireless World* Prize by the judges of the Amateur Competition at the B.S.R.A.

G. F. Johnson, author of the article "Television A.G.C. Circuit," graduated B.Sc. (Hons.) from Reading University in 1944, where radio was then treated as a complete subject and not merely a branch of physics. For the following two years he served in the Projectile Development Establishment of the Ministry of Supply. Since January, 1947, he has been at the Armament Research Establishment (M.o.S.), where he is an experimental officer. G. F. is a brother of K. C. Johnson, contributor of the articles on single-valve frequency-modulated oscillators in our April and May, 1949, issues.

E. A. R. Peddle, author of "Electronic Switching" (p. 421), graduated from University College, Exeter, in physics in 1947 and, after two years in the R.A.F. as an education officer, joined the G.E.C. Research Laboratories in 1950 as a member of the pulse communications group.

Canada's Television Service opened on September 6th with transmissions from the Montreal station. Two days later the Toronto transmitter came on the air. The studio equipment for both stations and also an outside broadcasting van for each was supplied by Marconi's.

E.M.I. "Long Play" Records.—It is announced that 45-r.p.m. 7in, as well as 33⅓-r.p.m. 10in and 12in records will be released this month by H.M.V., Columbia, Parlophone and M.G.M. The groove pitch will be of the order of 250 per inch and the base will be a new British plastic giving high mechanical strength and low surface noise.

Large-screen (4 × 3ft) monitor receivers were installed on each side of the stage in the Earls Court studio to enable members of the audience to see the transmitted picture in addition to the complicated set-up on the stage. The equipment was installed at the request of the B.B.C. by Aren (Radio & Television), Ltd., of Guildford, Surrey.

Marconi's have lent four transmitter-receivers to the British North Greenland Expedition which recently left London on a 26-month investigation. The sets, which operate on two "spot" frequencies in the 2.5-8.5 Mc/s band with a power of two watts, will be used for inter-communication when parties are working considerable distances apart. These sets have already undergone tests in the Malayan jungle.

British Display at the German Industries Fair in Berlin, which opened on September 19th, includes demonstrations by Pye of colour and under-water television. Also included in the British Pavilion, where the B.B.C. has an information bureau, is a display of Decca radar gear.

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Radio-controlled boats and aircraft will again be a feature of the *Model Engineer* Exhibition which will be opened by the Duke of Edinburgh at the New Royal Horticultural Hall, Westminster, on October 20th.

"**Elettra II,**" Marconi's research yacht, which is visiting Greenock (October 7th-18th), Belfast (October 21st-29th) and Dublin (October 29th-November 6th), has on board three new products for test and demonstration. These are the "Albatross" radio-telephone transmitter-receiver and two echometers, the "Graphette" recording sounder (140 fathoms max.) and "Visette" visual sounder (130 fathoms max.).

Dollar Exports.—B.T.H. has received from the U.S. Army, European Headquarters Command, an order for military electronic equipment valued at over £1,500,000.

Ambiguity.—Since the advertisement pages went to press it has been pointed out by A. R. Sugden & Co. that their announcement on p. 32 is ambiguous. The price quoted for the 3-speed motor does not include the pick-up.

Phone number of Radio Traders, Ltd., was incorrectly given in their advertisement on p. 18 of our September issue; it should be Gerrard 3977/8.

EDUCATIONAL

Technological Education. — Among the 200 or so advanced courses listed in the Bulletin of Special Courses in Higher Technology issued by the London and Home Counties Regional Advisory Council for Higher Technological Education are a number which may be of interest to *Wireless World* readers. They include acoustics, industrial electronics, high-vacuum technique, pulse techniques, radar principles, technical writing, television and valve technology. Thirty colleges are listed in the Bulletin which is obtainable, price 1s 6d, from the Secretary, Regional Advisory Council, Tavistock House South, Tavistock Square, London, W.C.1.

Intensive Courses in electronics and electrical engineering are provided by the South-East London Technical College. These full-time courses are divided into two sections; the first for students with little or no knowledge of electronics and the second for those who have completed Stage I or have some previous knowledge of the subject. The next Stage II Course, for which the fee is £6 13s 4d, will be held from October 6th to November 28th. The college is also providing an evening course in communication networks by Dr. W. Saraga. The fee for the course of twenty-four lectures, to be given on Fridays from October 24th, is £1. Details of each of these courses are obtainable from C. W. Robson, Head of the Electrical Engineering Dept. of the College, Lewisham Way, London, S.E.4.

Prospectus for the 1952-53 session of the School of Engineering, Burnbank, Hamilton, Lanarkshire, includes details of both full-time and part-time day and evening courses in radio and television servicing, audio engineering, telecommunications, industrial electronics and basic radio and television principles. A series of six lectures on colour television covering both the fundamentals and the present state of the art is also scheduled. Details are available from R. H. Garner, the principal.

> Secretaries who have not yet sent in details for our Club Directory, as requested in our last issue, are asked to do so by return otherwise it will not be possible for their entries to be included.

Amateur Exam. Courses.—Although the courses for the Radio Amateurs' Examination, arranged by the principals of the Brentford (Middx.) and Chichester (Sussex) Evening Institutes, will have begun by the time this note appears, students will still be accepted. At Chichester, where E. J. Pearcey (G2JU), late of the E.M.I. Group, is instructor, classes are held on Wednesdays at 6.30 at the Lancastrian Boys' School, Orchard Street, Chichester. At Brentford the classes are held at 7.0 on Wednesdays and the instructor is J. R. Hamilton of E.M.I.

MEETINGS

Institution of Electrical Engineers

Inaugural address of the president, Colonel B. H. Leeson, O.B.E., on October 9th.

Radio Section.—Address by E. C. S. Megaw, M.B.E., D.Sc., (chairman) on October 15th.

Discussion on "The Impact of Television on Sound Broadcasting," opener, G. Parr, B.Sc., on October 27th.

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

Cambridge Radio Group.—Address by K. N. Hawke, B.Sc., (chairman) at 6.0 on October 14th at the Cambridgeshire Technical College.

North-Eastern Radio Group.—Address by D. R. Parsons (chairman) at 6.15 on October 20th at King's College, Newcastle-on-Tyne.

North-Western Radio Group.—Discussion on "What Practical Benefits can Communication Engineers Expect from the Modern Information Theory?" opener E. C. Cherry, D.Sc. (Eng.), at 6.30 on October 22nd at the Engineers' Club, Albert Square, Manchester.

South Midland Centre.—Address by K. R. Sturley, Ph.D., B.Sc., (chairman) at 6.0 on October 6th at the Grand Hotel, Birmingham.

South Midland Radio Group.—"Why Quantum Theory Matters to Engineers" by D. A. Bell, M.A., B.Sc., at 6.0 on October 27th at the James Watt Memorial Institute, Great Charles Street, Birmingham.

Southern Centre.—"Introduction to the Theory of Information" by J. E. Flood, Ph.D., and L. R. F. Harris at 7.30 on October 10th at the R.A.E. College, Farnborough.

British Institution of Radio Engineers

London Section.—Annual General Meeting, followed by presidential address of W. E. Miller, M.A. (Cantab), at 6.30 on 8th October at the London School of Hygiene and Tropical Medicine, Keppel Street, London. W.C.1.

Scottish Section.—"Recent Developments in Television: Methods of Picture Generation" by H. McGhee (Pye. Ltd.). at 7.0 on 2nd October at the Department of Natural Philosophy. University, Edinburgh.

North-Eastern Section.—"Germanium Crystal Valves, their Characteristics and Application" by B. R. Bettridge at 6.0 on 8th October at the Institution of Mining and Mechanical Engineers, Westgate Road, Newcastle.

West Midlands Section.—"A Survey of Television Development and its Problems" by H. J. Barton-Chapple, B.Sc., at 7.15 on 28th October, at the Wolverhampton and Staffordshire Technical College, Wulfruna Street, Wolverhampton.

British Sound Recording Association

London.—"78, 45 and 33⅓ Records" by B. E. G. Mittell at 7.0 on 24th October at the Royal Society of Arts, Adelphi, London, W.C.2.

Portsmouth Centre.—Anunal exhibition and open evening from 5.0-10.0 on 16th October in the Council Chamber, The Guildhall, Portsmouth. H. Davies, M.Eng. (president), will lecture at 7.0.

Manchester Centre.—"The Electro-Acoustics of Radio Play Production" by Patrick Cambell (B.B.C.) at 7.30 on 20th October at the Engineers' Club, Albert Square, Manchester.

Television Society

"The Viewing of Moving Pictures" (film and television) by Dr. W. D. Wright (Professor of Technical Optics, Imperial College) at 7.0 on 1st October at Film House, Wardour Street, London, W.1. (Joint meeting with the British Kinematograph Society.)

"The Birth of a High-Definition Television System" by S. J. Preston, M.A. (Patent Dept., E.M.I.), at 7.0 on 24th October at the Cinema Exhibitors' Association, 164, Shaftesbury Avenue, London, W.C.2.

Bristol & South Western Centre.—"Large Screen (4ft × 3ft) Television" by D. V. Braun at 7.30 on 7th October at "Carwardines," Baldwin Street, Bristol, 1.

Physical Society

Acoustics Group.—"The American Acoustical Scene" by A. T. Pickles at 5.0 on 13th October at the Science Museum, London, S.W.7.

Institute of Physics

Electronics Group. — "Electrical Analogues." by Dr. G. Liebmann (Associated Electrical Industries), at 5.30 on October 14th at 47, Belgrave Square, London, S.W.1.

Radio Society of Great Britain

Programme of films, including first screening of 1952 National Field Day film, at 6.30 on 31st October at the I.E.E., Savoy Place, London, W.C.1.

Electroencephalographic Society

Annual general meeting, followed by papers, in the Physiological Laboratory, Cambridge, on 4th October.

Radar Association

Radar film show by Cossor, Ltd., at 7.30 on 7th October at the Bedford Corner Hotel, Bedford Square, London, W.1.

Institute of Navigation

Presidential address on "Navigation and Hydrography" by Rear Admiral A. Day at the annual general meeting at 3.0 on 17th October at the Royal Geographical Society, 1, Kensington Gore, London, S.W.7.

Society of Relay Engineers

"Television Wire Broadcasting—P.O. Testing of Licensed Systems" by C. F. W. Hawkins and G. H. Barlow (P.O. Local Line and Wire Broadcasting Branch) at 2.30 on 7th October at 21, Bloomsbury Street, London, W.C.1.

Guild of Radio Service Engineers

Annual general meeting at 11.0 on 5th October at the Market Hotel, Birmingham. 5.

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LETTERS TO THE EDITOR

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

V.H.F. in U.S. and U.K.

I HAVE read the views of J. R. Brinkley on v.h.f. broadcasting in the July *Wireless World* with considerable interest. I wonder if American experience, as reported by Mr. Brinkley, has any valid bearing on the situation in the U.K.

The land area of North America which constitutes I.T.U. Region 2 has only three principal countries requiring medium-wave channels. With some exceptions, centres of population are quite widely separated in North America. The situation here in I.T.U. Region 1 is considerably different both geographically and politically. There just are not sufficient medium-wave channels to adequately serve member states.

There has been very little compulsion in America to accept v.h.f. broadcasting because most large cities have from five to 15 active medium-wave channels available, with average to poor performance. Education of the average American listener to expect lower noise levels and wider bandwidth has until recently been hampered by poor performance of long-line circuits used in network broadcasting. The desirable trend in the direction of higher fidelity which started here is currently reaching large proportions in America.

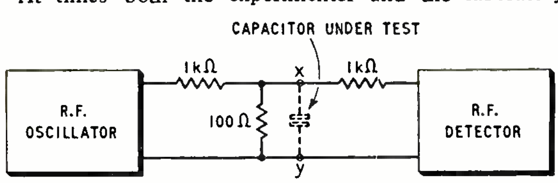
F.M. broadcasting will ultimately find universal acceptance for reasons which have been adequately demonstrated. In my opinion, the B.B.C. would improve listener service by radiating from the Wrotham v.h.f. station regular schedules of both the Home Service and the Third Programme on f.m.

London, W.2. C. VAN COTT.

"R.F. Characteristics of Capacitors"

THE article in your August issue by R. Davidson focuses attention upon a subject about which little has been published.

At times both the experimenter and the laboratory

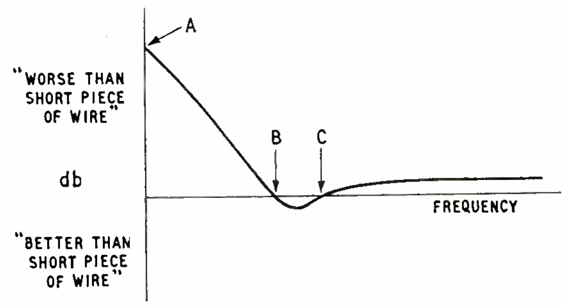


worker need a means of assessing the broad picture of the characteristics of capacitors at radio frequencies and the following method may be of interest to your readers.

Generally, a capacitor is required to have a very low impedance at radio frequency and the method here described compares the impedance of the capacitor under investigation with that of a short piece of wire, at various frequencies. (The term impedance of the capacitor is used, bearing in mind the inductance and resistance of the component and its leads.) The apparatus is shown in the diagram given above. The r.f. oscillator can be a commercial model with variable output and the r.f. detector can be a modified superhet receiver with a calibrated meter in the output stage.

The method is simple. Both the oscillator and detector are tuned to the same frequency and with a two-inch piece of wire across points *x* and *y*, the reading of the output meter is observed. Next the piece of wire is replaced by the capacitor under test and the meter reading again recorded. The difference between these readings is an indication of the amount by which the impedance of the capacitor differs from the impedance presented by the short lead.

A graph of this quantity plotted to a base of frequency shows several interesting points. Portion A—B is characterised by a high capacitive reactance; i.e., to cover this frequency range, a larger value of capacitance is indicated. From B—C there is series resonance in the



capacitor and its connections and this results in a lower "impedance" than that presented by the two-inch piece of wire. Above C the inductive reactance of the component and its connections becomes excessive.

Provided its limitations are borne in mind and that pick-up is reduced to a minimum, it will be found that this method provides a simple means of assessing the characteristics of medium-value capacitors at the lower radio frequencies.

Portsmouth. FRANK DELLOW.

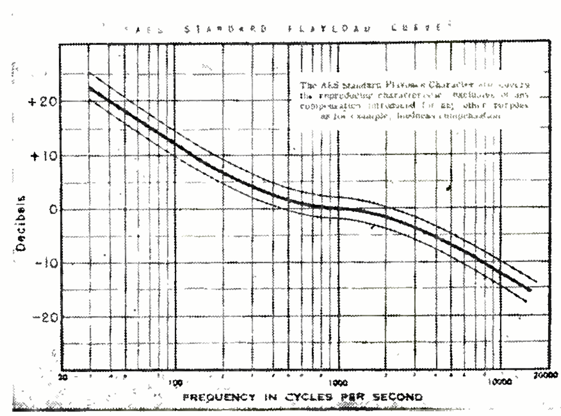
Too Many Recording Characteristics?

I FEAR that Ruth Jackson (your August issue) has just discovered the existence of a problem which *was* far worse than she thinks, but which already presents a solution. There are at least nine, not three, recording characteristics presently in use in the phonograph field.

Two years ago the Audio Engineering Society proposed the use of a standard *reproducing* characteristic. Use of this would permit reproduction of all present makes of records without change of circuit. At the present time all Capital records, and all material recorded by West Coast organizations, is made exactly to this characteristic. All the others are sufficiently close so that the A.E.S. characteristic is quite satisfactory.

C. J. LEBEL,
Secretary, Audio Engineering Society.
New York, U.S.A.

AS a result of my letter published in the August issue I have received from the Audio Engineering Society of America the accompanying curve of the reproducing



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characteristic the Society recommends should be adopted as standard.

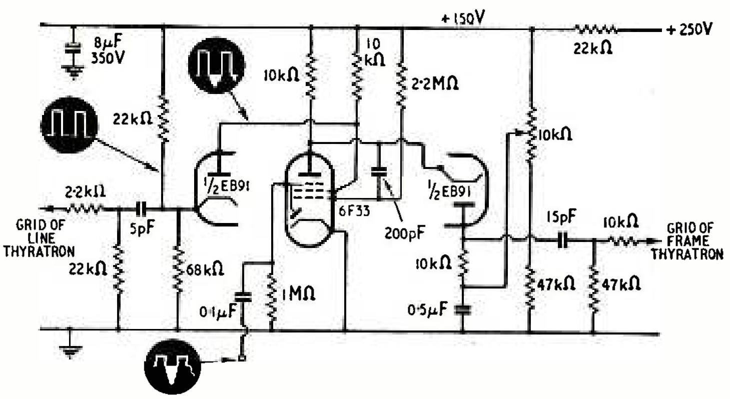
It will be noted that it is complementary to, and so provides correction for, a recording characteristic with a drop of approximately 5 db per octave from 800 to 30 c/s, that is flat from approximately 800 to 1,200 c/s, and rises in the order of $3\frac{3}{4}$ db per octave from 1,200 c/s upwards—this being, presumably, what the Society considers to be the best compromise between the ideal in recording and reproduction characteristics.

May I add, in self-defence, that the fact that the Society has taken the trouble to arrive at, and universally recommend, such a characteristic disposes of the criticisms levelled by R. Marker and Henry Morgan (September issue) against my reasons and plea for a standardized recording characteristic.

London, N.6. RUTH JACKSON.

"*Faulty Interlacing*"

I WOULD like to thank G. N. Patchett for his excellent sync separator circuit in the August issue. This circuit has been tried, and an excellent interlace is produced, but in its present form there is a considerable amount of picture content in the screen grid waveform, which can cause pulling of the line time base. This picture content is the complete vision waveform compressed to 20 per cent of the line pulse amplitude, and is due to the suppressor-to-screen capacitance. The defect can be overcome by the use of an additional diode biased to remove this picture



waveform. The accompanying circuit arrangement has been used to clear up this fault.

Weybridge, Surrey. J. E. ATTEW.

[Editorial Note.—G. N. Patchett comments on the above letter: I agree that there is some picture content in the screen grid waveform but my oscillograms show less than 10 per cent. This does cause slight pulling of the line time base which is visible on Test Card "C" but not normally noticeable on a picture. The magnitude of this pulling is increased by a large signal fed to the synchronizing separator. The use of a diode as suggested will remove this trouble and is probably worth while. The trouble could also be overcome by a simple sync separator to remove the picture content before this sync separator circuit.]

I HAVE been trying the sync separator described by G. N. Patchett in your August issue. As the tube in my receiver is grid-modulated and the output from the video stage therefore unsuitable, I fed the separator directly from the detector. The input thus obtained was rather small and I had doubts as to whether the separator would operate efficiently. However. the separator appears to work satisfactorily with an h.t. supply of 50 V. With a voltage somewhat greater than this V, could be cut off, with the input available, for the vision content of the signal.

The line structure and synchronization are rigid, the interlacing good, and the video output is now rather better for high frequencies since a separator is not operating from it.

I used VR 116 and VR 54 valves and the h.t. consumption at 50 V is 2 mA, rising to about 5 mA at 250 V.

London, W.4. R. V. SHARMAN.

Encouraging Morse Operating

IN two world wars radio amateurs have formed a useful nucleus of morse operators who could be readily trained for the Defence Services. The matter is of greater importance now that the Post Office no longer teaches morse and its competent telegraphists have mostly gone on pension in old age.

Perhaps by juggling licence fees the Post Office could usefully differentiate between exclusively morse operators and the hordes of radio-telephonists who monopolize the channels and are useless for defence purposes in time of war.

Ashford, Kent. WM. A. RICHARDSON.

Television Bandwidth

IT was a shock to hear from several manufacturers at the Radio Show that their television sets were not designed to reproduce greater definition than that provided by 2.75 Mc/s bandwidth. The usual reply to my query as to "why?" was "What is the use; the B.B.C. aren't giving any more." Two went so far as to say that this bandwidth is transmitted only on Alexandra Palace with its double sideband transmissions and not on the other vestigial sideband transmissions which were giving less.

On my own set (without obvious "ringing") a comparison between the detail of Test Card "C" and the average transmission from O.B.'s, studios and films alike shows that 3-Mc/s definition is there. Admittedly there are obvious factors which can occasionally spoil the definition such as bad focusing, poor lighting and, in some cases, cameras that seem incapable of giving the required definition in any circumstances. In each transmission, however, there are periods which demonstrate that the full bandwidth can be transmitted.

The aim, both of the B.B.C. and the manufacturers should be to maintain this standard. I quite believe that the B.B.C., as in its sound broadcasts, uses every endeavour to give us the highest quality that is technically attainable. Any sign of catering for a lower standard would indeed be a retrograde step on their part. On the manufacturers' side competition and pride alike should prompt them to give the best possible despite the exhorbitant purchase tax.

London, W.8. W. MACLANACHAN.

Capacitance Units

ALTHOUGH the maximum/minimum ratios of the values of capacitors and resistors used in radio have always been largely similar, the expression of these values, so far as resistors are concerned, has been greatly simplified by the symbols *M* and *k*. The stumbling block with capacitors has always been that ridiculous unit of capacity employed, the microfarad.

M. G. Scroggie's decision to adopt the nanofarad (your September issue) is commendable enough; the only possible objection is the chance of confusion, in workshops and elsewhere, between *M* and *n* because of verbal similarity. If capacitance was expressed in picofarads, we could use *M* and *k* as with resistors: thus 1 picofarad would become 1p; 1000 pf, 1 kp; and 1 microfarad, 1 Mp.

Kirkcaldy JAMES NICOL.

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ELECTRONIC SWITCHING

Part 1.—Principles of the Use of Cold-cathode Gas Discharge Tubes

By E. A. R. PEDDLE* B.Sc. (Hons.)

EXTENSIVE investigation into the phenomenon of the conduction of electricity in gases has led in recent years to the development and production of gas discharge devices that are stable and reliable in operation. The gas discharge tube has two possible states: one in which the gas is, for practical purposes, an insulator, and the other in which it is ionized and therefore conducting. It is this property which is utilized in switching applications.

There are three main advantages in using gas discharge devices for such purposes. The power consumption is low, there being no heater elements to absorb power as in thermionic valves, and the life is long, a service representing 10-20 years of life being possible. Compared with mechanical switches, there are no moving parts to wear out or to require frequent adjustment and cleaning, and maintenance is further simplified since the discharge is visible in operation so that faults can be easily traced by inspection.

Mechanism of Gas Discharge

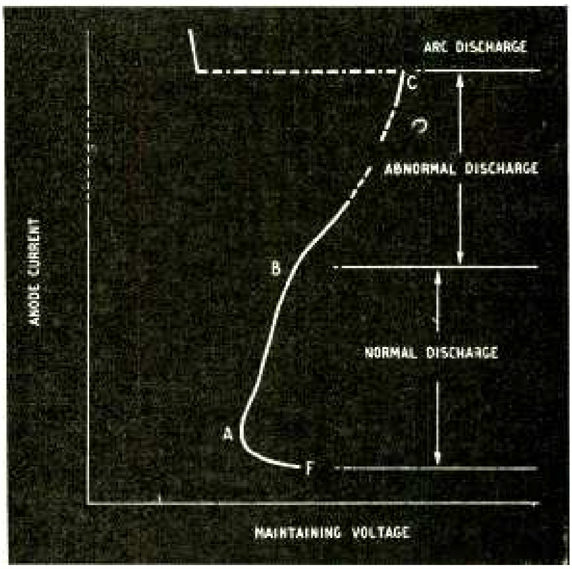
In construction the cold cathode discharge tube consists of two or more metal electrodes surrounded by a gas inside a glass envelope. The gas is usually neon or argon, or a mixture of these two, at a pressure of about 50 mm of mercury. The cathode is usually made of nickel or molybdenum and is often coated with an activating substance such as barium or potassium. The three principal characteristics of such a device are those relating to the transfer of the insulating to the conducting state (breakdown), the conducting state itself, and the return from the conducting to the insulating state (extinction).

The mechanism of electrical breakdown in gases depends for its action upon the presence of initial ionization in the body of the gas. Normally, external ionizing agents such as cosmic and ultra-violet radiations produce such initial ionization, which is equivalent to a current of the order of 10^{-12} amp. If a potential is applied between the anode and cathode of a cold cathode diode, a number of electrons, equal to the number produced in the gas by external ionizing agents, reaches the anode every second. As the applied potential is slowly increased, the moving electrons are accelerated and eventually gain sufficient energy to ionize the neutral atoms present by collision. Further ionization is then produced by secondary effects[1] and the current increases rapidly, a self-sustaining discharge taking place in the tube. The onset of this discharge is characterized by a sudden fall in potential across the tube. In practice a load resistor, used in series with the two electrodes, limits the discharge to a glow regime characterized by a luminous glow near the cathode surface and usually a more diffuse glow near the anode.

The applied potential at which the discharge and hence the current in the tube becomes self-sustaining is called the breakdown potential. Its value depends upon that of the initial ionization present. Operating a tube in darkness, for example, reduces the ionization due to external radiations, and so causes a considerable increase in breakdown potential. The breakdown mechanism occupies a finite time, which can be reduced by applying potentials greater than the breakdown potential. Breakdown times as low as 30 μsec or, in more complex devices, 5 μsec can be reached by this means.

When the tube is conducting, the potential between anode and cathode is called the maintaining voltage, and is a characteristic of the gas and the cathode surface. By coating the cathode surface with substances having a low work function, such as barium or potassium, maintaining voltages of the order of 50-90 volts can be obtained. The breakdown voltages are much higher, e.g., 150-250 volts, so that the drop in anode

Fig. 1. Maintaining voltage characteristics of a cold-cathode discharge tube.



* Research Laboratories of The General Electric Company.
[1] L. B. Loeb, "Problem of the Mechanism of the Static Spark Discharge," *Rev. Mod. Phys.*, 8, 267 (1936).

potential when the tube breaks down can be quite large.

The variation of maintaining voltage with anode current for a typical tube is shown in Fig. 1. From A to B, the cathode glow does not completely cover the cathode surface, the current density in the glow is constant and the maintaining voltage varies little with current. In the range A to B, which is determined by the area and nature of the cathode surface, the discharge regime is said to be normal, and tubes are usually operated in this condition. Above B, the glow completely covers the cathode surface and is no longer at constant current density. With further increase in current, the maintaining voltage also increases and the discharge is then said to be abnormal. When the point C is reached, the current increases rapidly owing to thermal emission from the cathode and an arc discharge occurs. This can cause rapid deterioration of the cathode surface, and tubes should preferably not be operated in this way.

In Fig. 1, it is seen that point A represents a minimum value of the maintaining voltage, and point F a minimum value of anode current below which the discharge will not maintain itself. These minimum values are called extinction values, and are usually of the order of 50μA or less.

A conducting tube may, of course, be extinguished by making a physical disconnection in the appropriate circuit. Other methods are to reduce the anode-to-cathode voltage or supply potential to a value below the extinction voltage, or to reduce the current below the extinction value. When the tube is extinguished,

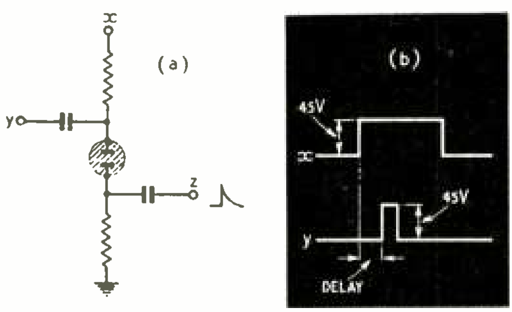


Fig. 2. Cold-cathode diode co-incidence gate (a), and (b) two typical co-incidence pulses.

Fig. 3. Experimental cold-cathode triodes, (a) 5-mA type and (b) octal-based version capable of handling up to 50 mA.

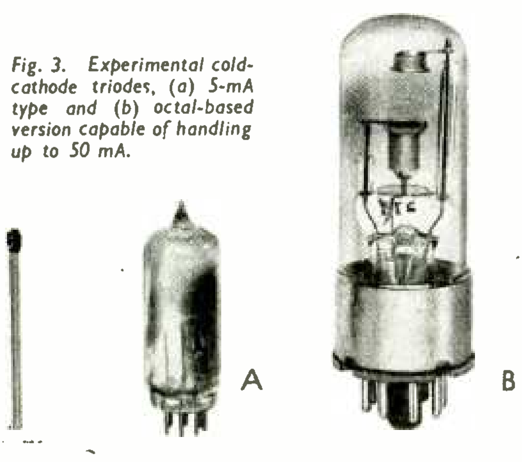


TABLE I
Typical Characteristics

DIODE		TRIODE (B7G TYPE)	
Breakdown Potential	60–80 volts	Anode Breakdown Potential	200–240 volts
		Trigger Breakdown Potential	85–100 volts
Maintaining Voltage	50–60 volts	Anode Maintaining Potential at 1 mA	80–90 volts
		Trigger Maintaining Potential at 1 μA	70–80 volts
Maximum Operating Current	1 mA	Maximum Operating Current	5 mA

the decay of the ionization takes a finite time. The extinction process must therefore be applied for a time long enough to ensure that, on re-application of the circuit conditions prior to breakdown, the residual ionization alone is insufficient to re-initiate breakdown. The minimum time required to extinguish the tube is called the de-ionization or extinction time, and varies according to the method of extinction, circuit parameters and conducting conditions. In practical applications the extinction time cannot be accurately estimated, and manufacturers' measurements made under fixed and stated conditions can only be a guide to the circuit designer. In general, the extinction time varies from 0.5 to 5 msec, which is very much greater than the breakdown time, and this relatively high value constitutes a serious limit to the speed of operation in many applications.

Electronic Gate

Cold cathode diodes which are suitable for use as switching elements are usually small in size, inexpensive, and wire-ended so that they can be soldered directly into circuits. They are also symmetrical, so that either electrode can be used as the cathode. Typical values for their main characteristics are given in Table I.

The most important application of such diodes is as an electronic gate, one variety of which is shown in Fig. 2(a). Here, neither of the applied pulses x and y is alone sufficient to cause breakdown or maintain a discharge. However, when x and y are coincident, as shown in Fig. 2(b), the anode potential is raised to 90 volts, which is sufficient to cause breakdown and produce an output potential z. The time delay between the application of x and y is necessary to allow the anode potential of the diode to reach 45 volts before the application of pulse y. If x were connected to an electronic store where information is represented as the presence or absence of a potential, then the diode could be used to read this information, the pulse y producing an output pulse at z if a potential has been stored.

The cold cathode triode [2,3] contains a third,

[2] A. L. Chilcot and F. G. Heymann, "Potassium-Activated Cold Cathode Tubes," *Jnl. Sci. Instr.*, 26, 289 (1949).

[3] W. E. Bahls and C. H. Thomas, "A New Cold Cathode Triode," *Electronics*, 11, 14 (1938).

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"trigger," electrode which can be used to initiate the discharge between the other two electrodes, the anode and cathode. The size of the tube varies according to its current-carrying capacity, from miniature 1-mA tubes to larger 5-mA B7G-sized tubes, Fig. 3(a), and octal-based types capable of operation at current of about 50 mA, Fig. 3 (b).

As stated above, the breakdown potential of a tube can be greatly reduced by increasing the initial ionization, and this is achieved in the triode by means of the trigger electrode. A potential smaller than the breakdown potential is applied to the anode, and one greater than the trigger-cathode breakdown potential is applied to the trigger electrode. Breakdown then occurs and current flows across the trigger-cathode gap, producing ionization which initiates a discharge between anode and cathode. The trigger current at which this occurs is called the transfer current, i_O, and varies with applied anode potential as shown in Fig. 4. Transfer can be obtained with very low values of i_O, enabling a low power stimulus to trigger the tube. For a given applied trigger potential, two factors influence the trigger current which passes when only the trigger-cathode gap is conducting. These are the maintaining voltage of the trigger gap and the trigger load resistor used to limit the discharge. The transfer current, and hence the triggering mechanism, can therefore be controlled by adjusting the value of the trigger load resistor, R_T. This is illustrated in Fig. 5, which shows the relation between anode potential and trigger potential necessary to trigger the tube, for various values of R_T.

The triggering time, which elapses between the application of the triggering potential and the onset of a self-sustaining discharge between anode and cathode, is composed of the breakdown time of the trigger gap and the time needed for transfer to take place. Fig. 6 shows the triggering time as a function of the triggering potential, again for various values of R_T. The effect of increasing anode potential or trigger bias is to decrease the triggering time.

Once the tube is conducting, the trigger electrode has no further part to play, and the triode is extinguished in the same way as the diode, i.e. by applying an extinction process to the anode-cathode circuit. In normal operation the trigger electrode is biased positively with respect to the cathode, and the tube is triggered by raising the bias potential to the required value. Since the bias potential is normally lower than the trigger gap extinction voltage, the trigger gap does not remain conducting when the main gap is extinguished. Typical values for the characteristics of cold cathode triodes are given in Table I.

Primed Tubes

In a special class of tubes, known as primed gap triodes, an auxiliary discharge is maintained in the tube. This is achieved by the insertion of an additional single electrode, the discharge taking place between it and another electrode, or an additional pair of the electrodes, the discharge taking place between them. The ionization from this discharge is insufficient to trigger the tube, and normal triggering techniques are used. The advantages of primed tubes are that the triggering potential can be stabilized, since breakdown is made independent of external conditions. Primed tubes are used in the same applications as non-primed triodes.

(To be concluded.)

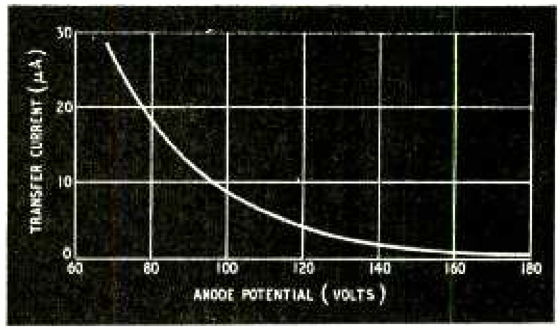

Fig. 4. Transfer current characteristics of cold-cathode triode with triggering electrode.

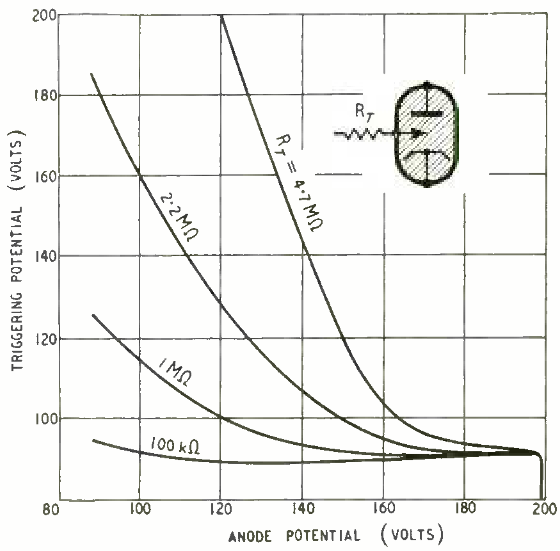

Fig. 5. Static triggering characteristic of a cold-cathode triode.

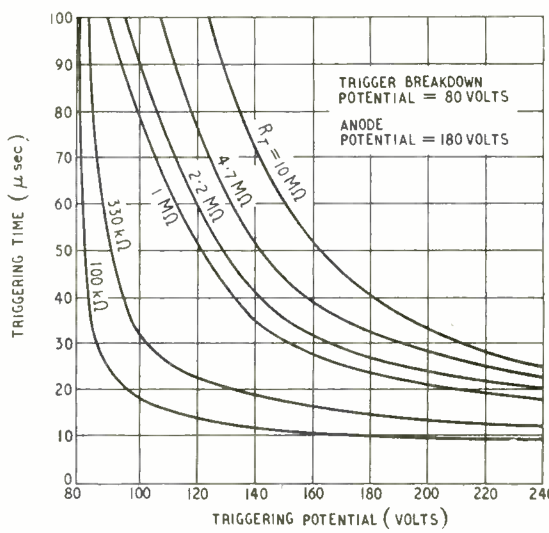

Fig. 6. Dynamic triggering characteristic of a cold-cathode triode.

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Television "A.G.C." Circuit

Simple System for Stabilizing Mean Brightness

By G. F. JOHNSON, B.Sc.

WHILE on holiday in Somerset, the author had the opportunity of seeing fringe area reception from the Sutton Coldfield television transmitter. The fading was such that the contrast control frequently needed resetting, and it seemed very desirable to provide some form of automatic control. However, only a few parts and tools (brought in case an elderly sound receiver had needed a tonic) were to hand.

In a television receiver, a bias voltage is effectively added to the video output voltage when the latter is applied to the cathode-ray tube. This bias is adjusted by the brightness control so that the beam current of the tube is almost cut off when the video output voltage corresponds to black level in the transmission. If too little bias is applied, the black parts of the picture will be illuminated to some degree; however, none of the shading detail of the picture will be lost. If the bias is excessive, the cathode-ray tube will remain cut off until the video signal rises sufficiently to overcome it, and the darker shades will be reproduced as uniform black. They are therefore completely lacking in detail, and the picture becomes very unrealistic. This is a form of distortion which has no counterpart in a purely optical system.

Fading of the signal with a constant setting of the brightness control will lead to the forms of distortion just mentioned, since the video output voltage corresponding to black level (30 per cent modulation at the transmitter) will change. The bias will therefore no longer have the correct value in relation to the signal. The brightness control may be altered to correct the black level of the picture, but the change in contrast due to the fading will still remain uncorrected.

If the gain of the receiver is altered to keep the black level video output voltage constant to correct for fading, both the black level and contrast of the received picture will remain unaltered. The gain is usually set by bias applied to one or more of the high-frequency amplifying valves. The contrast and sensitivity controls usually provide fine and coarse adjustments, respectively, of this bias.

If this grid bias could be obtained from the video output voltage in a suitable manner, automatic control of the gain of the receiver to combat fading could be obtained.

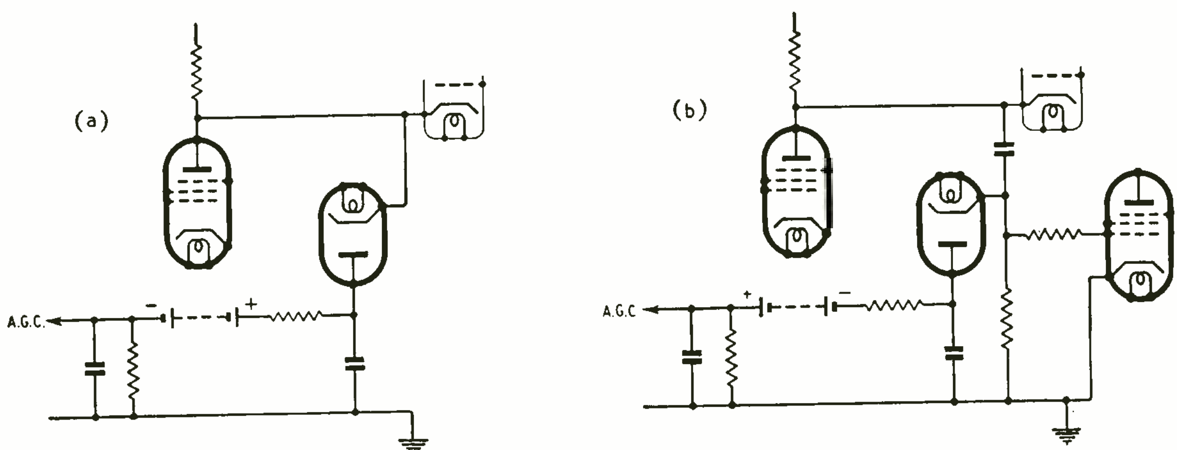
Possible Methods

With the negative modulation system (used in America and certain other countries) the sync-pulse tips represent 100 per cent transmitter modulation. All that is necessary, therefore, is to arrange the a.g.c. to maintain constant the peak video output voltage. A voltage delayed diode, together with a capacitor circuit having a discharge time constant long compared with the charge time constant, may be used to accomplish this.

Such a diode circuit is sometimes used for limiting impulsive interference in British receivers, and Fig. 1 shows ways of obtaining a.g.c. voltage by modifying the limiter circuit. With the positive-modulation system, used in Britain, however, 100 per cent transmitter modulation corresponds to brightest white (termed "peak white"). An a.g.c. circuit of this kind would enable correct reproduction only if peak white were always present in the transmitted picture; consequently it is hardly a practical method.

The ideal solution would be to arrange the a.g.c. circuit to sample the video signal and maintain con-

Fig. 1. Possible ways of obtaining a.g.c. voltage from interference-limiting diode



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stant its black-level value. It would, however, demand a good deal of extra equipment and, almost certainly, the addition of one or more valves. The provision of a "Black Level Clamp" to fix the voltage of black level in the video output irrespective of fading would be nearly as complicated.

In some receivers, a d.c. restoring diode is used following a capacitance coupling for the video signal. The diode serves to fix the sync-pulse tips at some chosen potential by rectifying a small part of them to provide the necessary bias. If this diode were cut off for the duration of every sync pulse, it would be unable to fix the voltage of the sync-pulse tips, and could be made instead to clamp the black level of the video signal at some chosen potential.

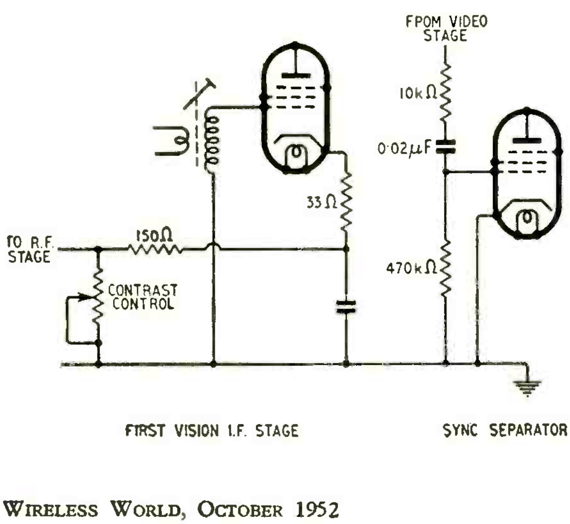
If the d.c. component of the video signal is omitted in the receiver by using a capacitance coupling for the video signal, and if no d.c. restoring diode is used, the effect of signal variations due to fading and reflections from moving objects is made less noticeable.[1] This is because a constant voltage (whose value is set by the brightness control) is inserted in place of the d.c. component (i.e., the true average value of the signal) and the signal appears to have a constant average value equal to this. Variation of the signal does not then greatly affect the brightness of the picture, although the contrast and the black level change.

The disadvantages resulting from loss of the d.c. component are, in practice, not as great as one might expect. There is very little noticeable error in the black level, as set by the brightness control, except during a programme fade-out or the transmission of a dark scene. In these cases, the black parts of the picture become light and the frame fly-back lines become visible.

The effect on a fade-out is obviously not of much importance. To obtain correct reproduction of a dark scene, however, it is necessary to readjust the black level. In the author's experience this is frequently the case with a normal receiver, as the black level often appears to be reduced in the transmission to represent darkness, instead of remaining constant while the contrast is reduced. This change of black level is in the opposite direction to that produced by omitting the d.c. component in the receiver, and the two effects cancel to some extent.

[1] A. H. Cooper, "Television Interference By Aircraft," *Wireless World*, April 1949, p. 142.

Fig. 2. Parts of receiver before modification.



If, on the other hand, the d.c. component of the signal is retained in the video amplifier but is also applied to an a.g.c. circuit, it may be kept nearly constant irrespective of fading of the received signal or changes in the transmitted picture. However, unlike the case in which the d.c. component is omitted, the receiver contrast will vary with the nature of the transmitted picture in such a way as to maintain constant the average value of the signal. Fortunately, this variation of contrast is in general small, and reception is as satisfactory as that obtained with the d.c. component omitted, with the added advantage that the effects of fading are very much reduced.

The modification needed to obtain this performance is often relatively simple. The writer tried out the idea on a receiver which had, for its relevant parts, the circuit of Fig. 2. The receiver (a Cossor superheterodyne used with a single-valve pre-amplifier) has an r.f., stage frequency changer, two sound i.f. and two vision i.f. stages. All these use 6AM6 (equivalent to EF91 or 6F12) valves. The contrast control operates on the cathode circuits of the r.f. and first vision i.f. valves. These include at the cathode an unbypassed resistor of 33 Ω to reduce the change of input impedance resulting from a change in bias. A.g.c. is applied to the first sound i.f. stage.

Since the fading of the sound signal occurred at different times from that of the vision signal, it was decided to keep the gain of the common stages at maximum. This had the added advantage of providing the highest available input to the frequency changer, and resulted in a slight improvement in signal to noise ratio.

Sync-Separator Action

The grid circuit of the synchronizing separator was found to be as shown in Fig. 2. The series resistance (in series with the output impedance of the video stage), and the grid-leak resistance, control the slicing action of the separator. They are chosen so that the valve changes between the non-conducting and the conducting state over a range of the input signal which does not extend to either limit of the sync-pulse amplitude under normal conditions. With the component values shown, a rough calculation[2] (assuming an input signal with black level at 30 per cent where peak white is 100 per cent) shows that slicing takes place at about 19 per cent for an all-white signal and at about 6 per cent for an all-black signal. The average values of the signal are approximately 85 per cent and 27 per cent for white and black respectively. The average voltage across the 470-kΩ leak (assuming that slicing takes place and grid current starts at $V_g = 0$) is given by the difference in the figures above; i.e., 66 per cent of the peak white video output voltage for an all-white signal and 21 per cent for an all-black signal. These figures are, as might be expected, in the same ratio as those for the average values of the signal. For a video signal of -30 volts peak white, the voltage across the leak would thus lie between the extremes of -20 volts and -6 volts.

For maximum gain, the control-grid circuit of the first i.f. amplifier is returned to chassis potential. For anode current cut off, the bias needed will be about -5 volts. If a constant difference of average voltage could be maintained between the grid of the first i.f. amplifier and the grid of the sync separator, the average voltage of the latter would not change by

[2] W. T. Cocking, "Television Receiving Equipment," (Iliffe).

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more than five volts provided that the signal was within the range over which control was held by the i.f. valve.

Effective a.g.c. action is thus obtainable without any additional amplifier, particularly if more than one stage is controlled by the a.g.c. voltage. Control should not, of course, be applied to the last high-frequency valve, since it would become unable to provide the necessary undistorted output.

Practical Circuit

A battery, together with a resistance-capacitance circuit for averaging, could be used to maintain the voltage difference. It is, however, desirable to be able to vary the voltage at will, and inconvenient to incorporate a battery in a mains-operated receiver. Fortunately, a constant average voltage may be maintained across the sync-separator grid leak by simply feeding a constant average current through it. The circuit is shown in Fig. 3.

The 2.2-MΩ resistor (together with the voltage-dividing network formed by the 150-kΩ fixed and the 100-kΩ variable) forms an adjustable current source, having a resistance which is high compared with the sync-separator grid leak. The 0.1-μF capacitor completes the grid return of the valve at intermediate frequencies and, together with the high source resistance of the control voltage, forms an averaging (smoothing) circuit for the bias. In the superheterodyne receiver, the insertion of this capacitor did not have any noticeable effect on the performance, although investigation of the i.f. response curve might have revealed slight mistuning of the grid circuit. In the case of a t.r.f. receiver, it would probably be essential to use a separate ceramic or mica capacitor for the r.f. grid return, and even then to retune the circuit. Any damping resistor present should remain connected across the coil; if taken to chassis it would short circuit the a.g.c. voltage. The metal rectifier (Westector) was included to prevent the i.f. valve bias becoming positive in the absence of sufficient video signal.

In modifying a second receiver of the same type, a 1N22 crystal was tried but proved to have too small a reverse resistance to be of any use, since a value greater than about two megohms is needed.

The initial grid bias is altered slightly because of the voltage drop across the rectifier The cathode-bias resistor of the first i.f. stage could be changed to compensate for this; but since it provides negative current feedback for d.c., the change in anode current is about halved. It is thus unlikely that the valve will be overrun. If a thermionic rectifier were used, the residual grid bias would be negative and the maximum gain slightly reduced.

Seen from the 0.1-μF capacitor, the impedance of the sync separator for low frequencies is somewhat higher than the value of the leak. The time constant of the averaging circuit is given by this impedance, in parallel with the resistance of the current source and the leakage resistance of the rectifier, multiplied by the capacitor value. With the values used, the time constant is about 0.035 second or nearly twice the frame scanning period. This gives the a.g.c. a rapid action, and may actually result in horizontal streaking of the picture if the brightness is unevenly distributed vertically, since the contrast will then vary slightly during the frame scan. The rapid action is, however, very effective in removing flicker caused by reflections from aircraft. A capacitor value of 0.25 μF or more could be used if a slower action were desired.

The negative a.g.c. voltage at the earthy end of the sync separator grid leak will cause a slight reduction in the signal level at which slicing takes place in the sync separator. This effect is a minimum for weak signals, where clean separation is most important, and is quite negligible.

Performance

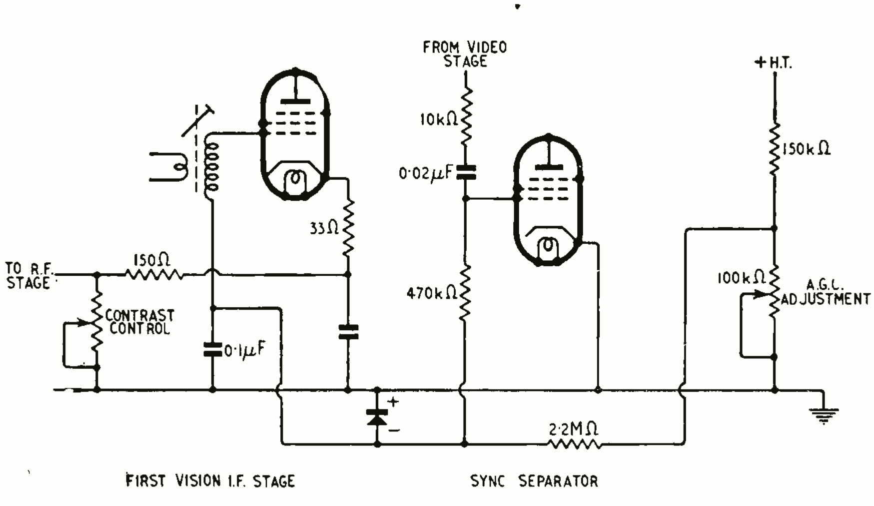
The a.g.c. adjustment was arranged as an armchair control. For a.g.c. use, the contrast is set at maximum. The contrast control may be used in the ordinary way if the a.g.c. adjustment is set at maximum. Normal operation of the receiver is thus not prevented by the modification, and a rapid comparison of reception with and without a.g.c. may be made at any time.

When using a.g.c., the armchair control is set to suit the requirements of the particular programme, and in practice may not require readjustment for a matter of hours. The occasional obvious error in the black level may easily be remedied, and is a very minor disadvantage when compared with the fading previously experienced.

The modification was carried out without removal of the receiver chassis from the cabinet, sufficient access being gained by the removal of the bottom panel. The usual precautions necessary with a live chassis receiver were taken.

Although the system is not an ideal one, in that it varies the receiver gain in accordance with the mean brightness instead of the black level, it does in practice result in improved performance, and its great simplicity makes it easy to try out. It may thus find much application in cases where the complexity and additional equipment of an ideal method make it inappropriate.

Fig. 3. Final form of automatic gain control circuit.



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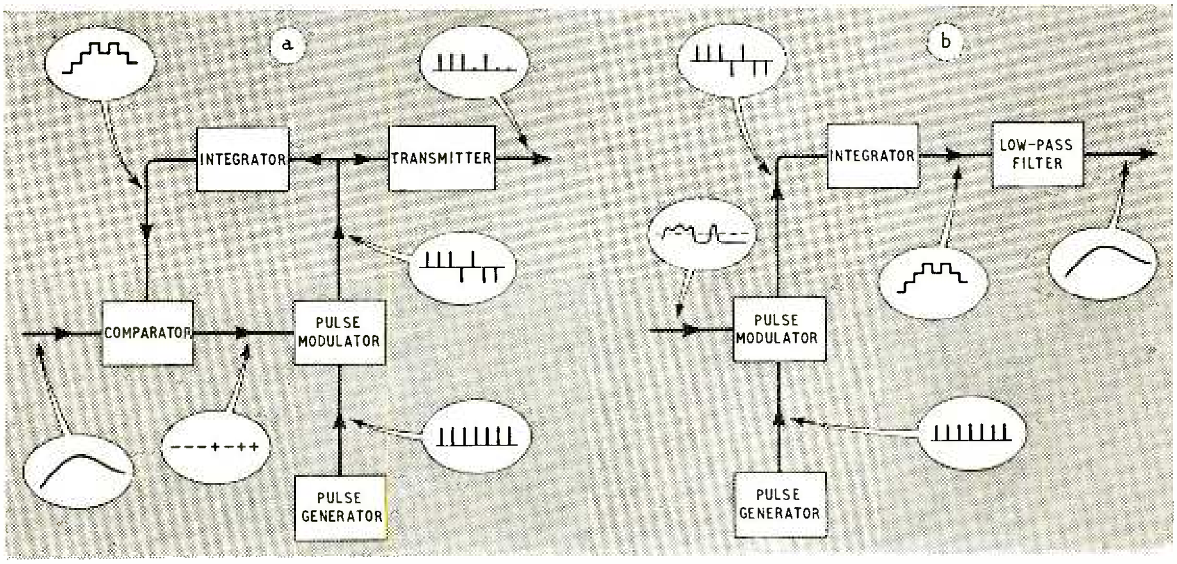
DELTA MODULATION

Transmitter Using Quantized Feedback



Block diagram showing the essentials of the system. The transmitting equipment is at (a) and the receiving equipment is at (b). The waveform at the receiver input is a badly-distorted version of the pulse train radiated from the transmitter.

ONE of the many interesting papers read at the recent symposium on applications of information theory at the I.E.E. described a new and somewhat unusual form of pulse modulation. It is a coded system, but differs from conventional pulse code modulation in that it transmits *changes* in the modulating waveform rather than actual voltage levels. In fact, another name for the system might be "servo modulation," for these transmitted changes are actually the "error-signals" of a kind of servo loop in which the modulating waveform is compared with an approximating waveform that tries to follow it all the time. Like ordinary p.c.m., delta-modulation is less vulnerable to interference than non-coded systems of pulse modulation, but has the advantage over p.c.m. that it does not require such complicated equipment.

The essentials of the equipment are shown in the block diagram. At (a) a pulse generator produces a train of equidistant pulses which go through a pulse modulator to the transmitter. In the pulse modulator their polarity is either left as it is or reversed, according to the polarity of a difference voltage obtained by comparison of the modulating waveform with the approximating waveform as mentioned above. This approximating waveform is produced by passing the pulses from the modulator through an integrating network, where each unchanged pulse raises the output voltage a certain amount and each reversed pulse lowers it an equal amount; the result being a staircase-type waveform which follows the ups and downs of the modulating waveform as shown. If, when a new step is to be added to the staircase, the modulating signal is greater than the staircase signal, it is an indication that the modulating waveform is rising and will probably continue to rise; the polarity of the difference voltage, or error-signal, is then such as to cause the pulse modulator to send an unchanged pulse to the integrator, so that the staircase waveform also rises, by one step. Similarly, if the modulating signal is smaller, its waveform is probably falling, so a reversed pulse goes to the integrator and the staircase waveform also falls. Actually the transmitter only radiates the unchanged pulses (staircase ascending), so the reversed pulses (staircase descending) are represented simply by gaps in the pulse train.

The function of the equipment at the receiving end (b) is to reconstruct the staircase waveform from the "up-or-down" type of information given by the pulses coming in from the receiver. To do this it uses a chain of apparatus similar to that in the transmitter. A local pulse generator (synchronized with the one in the transmitter) sends pulses to a modulator, which determines their polarity according to the polarity of the received error-signals. The train of mixed pulses so produced is then converted by another integrating network into a replica of the original staircase waveform. Finally, a low-pass filter smooths out the steps and a continuous waveform is obtained that closely resembles the original modulating waveform.

In the course of transmission the pulse train may become badly distorted, as shown, as a result of interference, but the shape of the received pulses does not matter very much as long as they can at least indicate their presence or absence. The interference, in fact, can be as much as half the pulse amplitude before it has any perceptible effect on the final reconstituted waveform at the receiving end.

A description of the system was also given by J. F. Schouten, F. de Jager and J. A. Greekes in the March, 1952, issue of the *Philips Technical Review*.

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F.M. FEEDER UNIT

(Concluded from page 338 of previous issue.)

Part 2.—Constructional Details and Alignment Procedure

By S. W. AMOS,* B.Sc. (Hons.) A.M.I.E.E., and G. G. JOHNSTONE,* B.Sc. (Hons.)

THE general layout of the feeder unit can be seen from the various illustrations and the wiring is quite straightforward, but care should be taken to keep connections as short as possible particularly in the r.f. and oscillator sections. As suggested in the full circuit diagram all earth connections for a particular valve are returned to a common earth connection, actually a tag secured to the chassis by one of the valve-holder bolts. One side of the valve heater, and the r.f. bypass capacitor from the other side of the heater, are returned also to this same earth connection.

COIL DATA

Circuit position	Circuit reference	Details
Aerial coil	L1 ..	1 turn 26 s.w.g. enamelled copper, interwound at earthy end of L2.
	L2 ..	5 turns 26 s.w.g. enamelled copper, occupying 0.3 in.
R.F. Anode coil	L3 ..	5 turns 26 s.w.g. enamelled copper, occupying 0.3 in. Wound as continuation of L4, and spaced 0.3 in from latter.
	L4 ..	3½ turns 26 s.w.g. enamelled copper, close wound bifilar-winding with L5.
	L5 ..	3½ turns 26 s.w.g. enamelled copper, close wound bifilar-winding with L4.
Oscillator	L6 ..	4 turns 18 s.w.g. tinned copper, tapped at 1¼ turns from earthy end, occupying 0.5 in.
1st i.f. transformer	L7, L8	Both 24 turns 40 s.w.g. enamelled copper close wound. 0.4 in gap between windings.
Detector unit	L9 ..	24 turns 40 s.w.g. enamelled copper close wound. 0.5 in. gap between L9 and L11.
	L10	4½ turns 40 s.w.g. enamelled copper close wound over top ("cold") end of L9.
	L11	18 turns 32 s.w.g. enamelled copper, wound as bifilar (9 turns each section), occupying 0.45 in.

All coil formers Aladdin type 5892; dust iron cores Aladdin type PP5804. Details of i.f. transformer and detector unit wiring see Figs. 3 and 4.

* *B.B.C. Engineering Training Dept.*

All the inductors in the unit, including those in the i.f. transformers are wound on Aladdin formers type 5892 of 0.415 in diameter. These are internally threaded to take dust-iron tuning slugs used for adjustment of inductance, those used being the Aladdin type PP5804. It has been found advisable to wax the threads of the dust-iron cores before insertion in the formers to ensure freedom from play and to ensure that the cores remain in position when adjusted. Alternatively a strand of cotton wound in the threads may provide sufficient packing for the purpose. The cans for the i.f. transformers are 1½ in square by 3 in high and can be obtained on the surplus market. A short description of each coil follows but, for ease of reference, complete winding details of all inductors are given in the table.

The aerial coil comprises 5 turns of 26 s.w.g. enamelled-copper wire wound to occupy approximately 0.3 in length on the former. The aerial coupling winding consists of a single loop of the same guage wire interwound with the 5-turn coil at its earthy end. To facilitate winding, a layer of transparent plastic tape is first wound on the former with the adhesive side outwards; this retains the wire in position as the turns are put on. When the winding is completed, a further layer of the tape (with adhesive side inwards) is placed over the winding. This affords some protection and also prevents movement of the turns; the technique is used with all coils with the exception of the oscillator coil.

The r.f. anode coil is of somewhat more complex construction. The winding connected between V_1 anode and cathode is in two sections, one forming the series inductor L_3 and the other the primary winding L_4 of the transformer. L_3 consists of 5 turns of 26 s.w.g. enamelled copper wire spaced to occupy a winding length of 0.3 in and L_4 consists of 3½ turns close wound, bifilar fashion, with L_5. There is a space of 0.3 in between the two sections of the coil. The secondary winding L_5 also comprises 3½ turns of 26 s.w.g. enamelled copper wire. A single tuning core is used and is adjusted during alignment for maximum output.

The oscillator coil consists of 4 turns of 18 s.w.g. tinned copper wire wound to occupy a length of 0.5 in. The coil is tapped at 1¼ turns from the bottom (earthy end) to connect the coupling winding from the r.f. stage. The ends of the coil are connected, one directly to earth and the other to a tag of a three-way tag strip mounted on one of the fixing bolts for the coil former. This arrangement ensures a rigid mechanical construction.

The construction of the first i.f. transformer can be seen from Fig. 3. The end cheeks and the coil formers are held in position by nuts on two 6 B.A. threaded rods which are used to fasten the assembly

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to the chassis. In this way the assembly is mounted independently of the screening can and the latter can be removed without dismantling the assembly.

The end cheeks are of sheet paxolin, 1.4 in square, the corners being clipped to clear the screening cans. A centre hole ¼ in diameter is drilled in each cheek to permit insertion of a trimming tool for tuning. The lead-out wires are supported at the end cheeks in four holes drilled at the corners of a square of 0.7-in side. The holes are bushed with eyelets in which the wires are soldered; the eyelets are of a type readily available for other purposes and can be obtained from leather and handicraft shops. Various other methods of securing the lead-out wires were tried but found unsatisfactory.

Both primary and secondary windings comprise 24 turns of 40 s.w.g. enamelled copper wire, close wound, the windings being positioned on adjacent ends of the formers so that they are separated by a distance of 0.4 in. Each winding is tuned by a fixed capacitor of 10 pF which for convenience is soldered to the lead-out wires at the eyelets in the adjacent end cheek.

As shown in the illustrations the assembly of the second i.f. transformer (detector unit) is similar to that of the first, employing 6 B.A. threaded rods to support the coil formers and end cheeks. A third paxolin panel is used in this assembly between the two formers, to provide additional anchoring points. Allowance must be made for the thickness of this panel when winding the coils to obtain the required 0.5-in spacing between adjacent ends of the primary and secondary windings. The two end cheeks are similar to those of the first i.f. transformer in dimensions, and drilling, but the top cheek has two extra eyeletted holes 1.1 inches apart arranged symmetrically about the centre and lying on a line at right angles to that passing through the threaded rods. The centre cheek is similar to the top one but does not require the large centre hole. The bottom cheek is similar to the top also but only one of the additional eyeletted holes is required.

The primary winding comprises 24 turns of 40 s.w.g. enamelled copper wire close wound and enclosed between layers of plastic adhesive-tape. The winding is tuned by the 10-pF capacitor soldered to the lead-out wires at the eyelets in the top end cheek. The tertiary winding is wound over the upper end of the primary winding, on top of the plastic tape, and consists of 4½ turns of 40 s.w.g. close wound. One end of this winding is brought out to the upper end of a 47-ohm resistor situated between the lead-out wires of the primary winding; the other end of the winding is soldered to the eyelet on the opposite

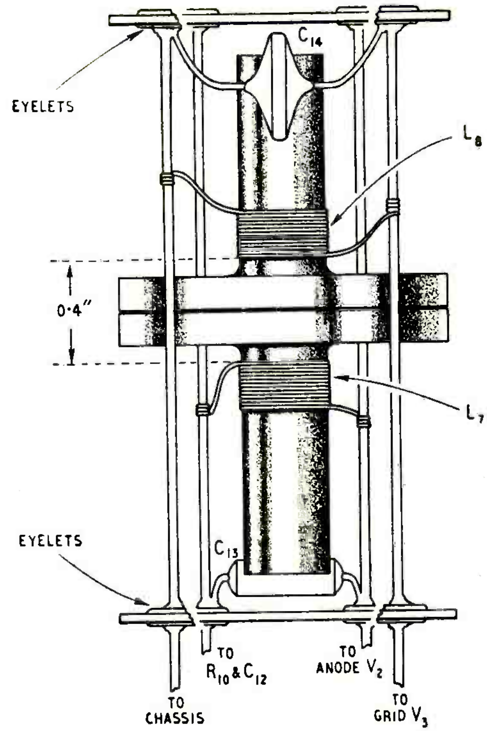
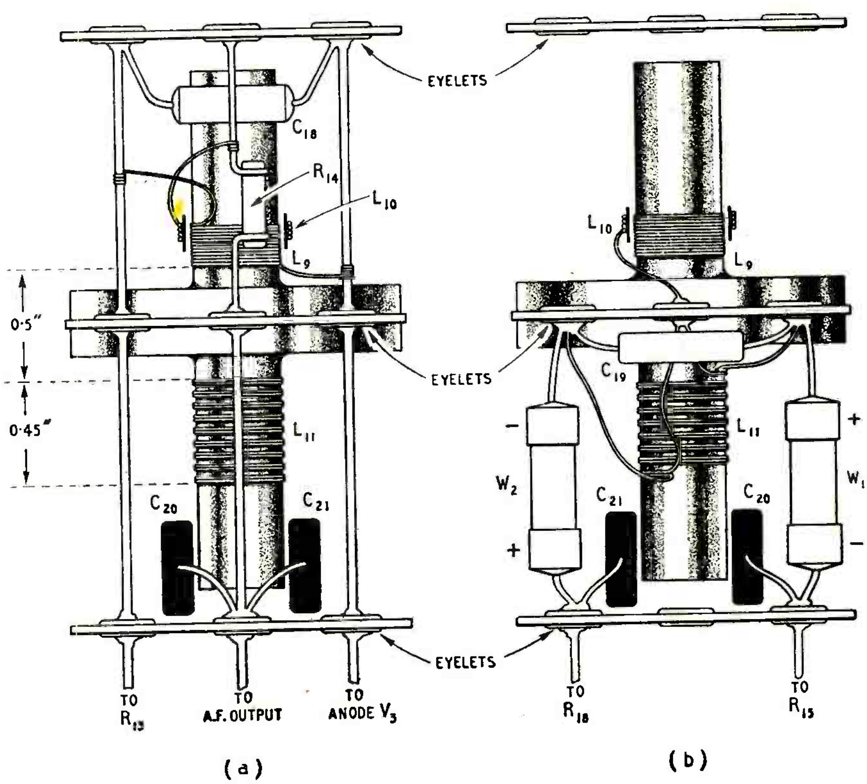


Fig. 3. Details of first i.f. transformer assembly.

Fig. 4. Constructional details of the detector unit (a) as seen from panel (b) as seen from back of set.



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side of the centre panel. It is important that the tertiary winding is wound over the " cold " end of the primary winding and care should be taken to ensure that the upper end of the primary winding is taken to h.t.

The secondary winding is of bifilar construction each section consisting of 9 turns of 32 s.w.g. enamelled copper wire enclosed between layers of plastic adhesive tape. The length of this double winding is 0.45 in which necessitates the turns being spaced. Care should be taken, however, to ensure that the two windings are in close proximity to each other throughout their length. The secondary centre tap is obtained by connecting one end of one of the bifilar windings to the opposite end of the other; these two ends are soldered to the eyelet in the centre paxolin panel to which one end of the tertiary winding is soldered. The remaining two ends of the bifilar windings are soldered to the remaining eyelets in the centre panel. These eyelets also anchor the lead-out wires of the crystals and the 35-pF secondary tuning capacitor. The two capacitors C_{20} and C_{21} are also mounted inside the detector unit; one lead from each capacitor is soldered in the eyelets in the bottom end cheek to which the crystals are also soldered. The remaining capacitor leads are soldered to the vertical wire situated between the leads to the primary winding; this wire is soldered in an eyelet on the centre panel with the 47-ohm resistor. The lower end projects through the bottom end cheek and carries the a.f. output from the detector unit. The capacitor C_{22} is connected to this output lead outside the detector unit. Details of this unit are given in Fig. 4.

Care should be taken in soldering the crystal end-wires because crystals are very prone to damage by heat; a thermal shunt should be placed on the wires when these are being soldered. A pair of point-nosed pliers can be used to grip the wires during soldering but a better method is to employ a thermal shunt made by soldering two strips of copper to the jaws of a crocodile clip as shown in Fig. 5. The shunt is clipped over the crystal end-wire, which is soldered as quickly as possible, and allowed to remain in position until the joint has cooled.

If a diode valve is used in place of the crystals the wiring of the second i.f. transformer is slightly different. The two eyelets between which each crystal is soldered carry a lead-out wire, one of which goes to the anode of one diode and the other to the cathode of the other diode. The capacitors C_{20} and C_{21} must be mounted outside the transformer because they are connected to the diode electrodes.

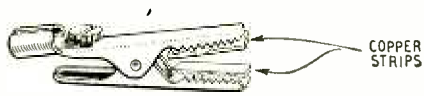


Fig. 5. Thermal shunt made from a crocodile clip as explained in the text.

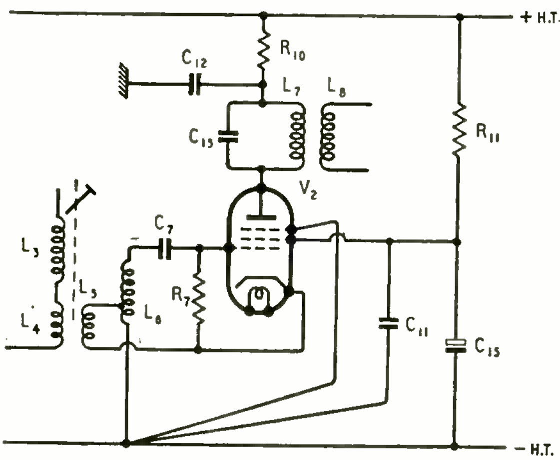
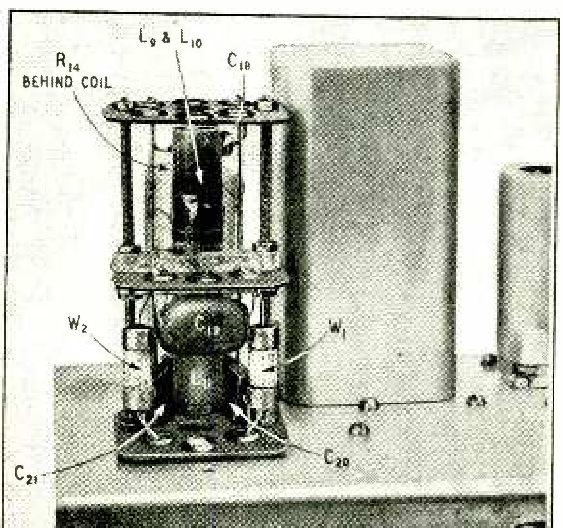


Fig. 6. An alternative frequency changer circuit to that shown in Fig. 1 (Part 1) enabling several components to be omitted.

Since Part I of this article was written, it has been found that certain components in the frequency-changer circuit can be omitted without effect on the performance of the unit. Primarily, the change comprises the omission of R_8 and C_6. R_8 was originally included to carry the d.c. cathode current of V_2 and C_6 was a blocking capacitor. However, it is quite permissible to omit C_6, and permit the d.c. to return to earth via L_5 and L_6. R_8 is then redundant. As a consequence the d.c. cathode potential of V_2 is zero with respect to earth, and the suppressor grid can be connected directly to the earth tag, R_9 and C_{10} being no longer necessary. The revised frequency changer circuit is shown in Fig. 6.

Arrangement of the components comprising the detector unit. The annotation enables them to be identified from the circuit diagram.



Alignment Procedure.—The unit should be switched on for at least 10 minutes before any alignment is attempted. Connect a voltmeter across the capacitor C_{25}. Ideally the meter should have a high impedance but a meter of 1,000 ohms per volt set to the 10-volt range can be used. Connect a signal generator output between the grid of V_3 and earth, and set the generator frequency as accurately as possible to 10.7 Mc/s and the output to approximately 50 mV. With a trimming tool adjust the two dust-iron cores of the detector unit for maximum meter reading. Transfer the meter to between the junction of R_{14} and C_{23} and earth; then re-adjust the core of the secondary winding to give zero output.

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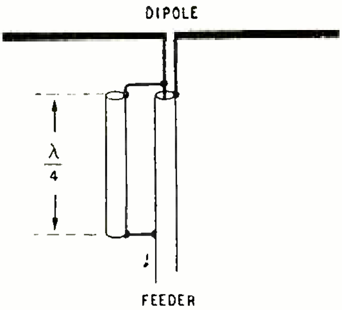
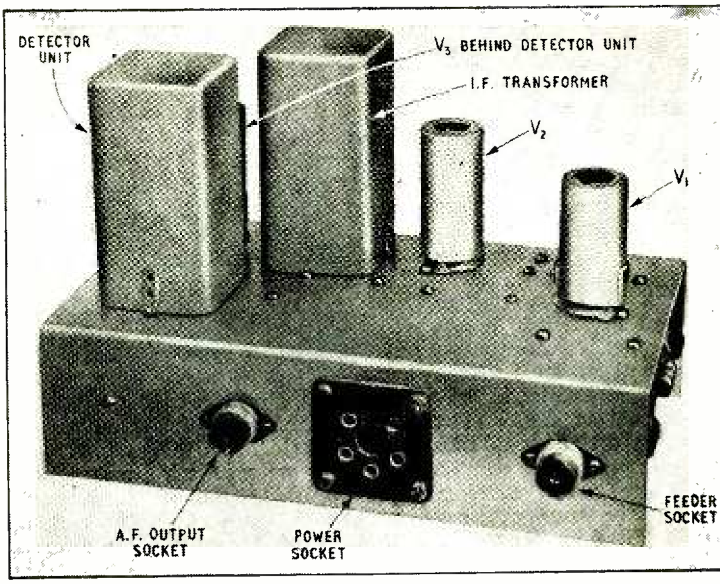


Fig. 7. Balanced-to-unbalanced coupling to the dipole for a coaxial feeder.



View of the receiver from the back showing input and output sockets, also power supply entry.

Reconnect the meter across C_{25} and re-adjust the slug of the primary winding for maximum output; only a very small readjustment should be necessary.

Connect the signal generator output between the anode of V_1 and earth, a blocking capacitor being used to prevent short-circuiting the h.t. supply; the capacitance of the blocking capacitor is not critical and 0.001 μF is suitable. The signal generator should be set to give approximately 500μV and the two cores of the first i.f. transformer are adjusted for maximum meter reading.

Two methods of aligning the oscillator and r.f. coils are possible. If the signal generator covers the range 80-100 Mc/s (either directly or on harmonics) connect it between the aerial input and earth and set the frequency to 87.5 Mc/s with an output of 500 μV. With the receiver oscillator tuning capacitor set to maximum capacitance adjust the oscillator coil dust-iron core to give maximum reading on the meter. If a meter reading is obtained at two positions of the core, that corresponding to the greater inductance should be taken. If the generator is amplitude-modulated, it should be possible to hear the modulation tone as the signal is tuned in. Check that the upper end of the band is approximately 100 Mc/s. If the tuning range is less than 87.5-100 Mc/s, the capacitance of C_8 should be increased; if greater, the value of C_8 should be reduced. If C_8 has to be changed, re-alignment at 87.5 Mc/s is imperative before the coverage is again measured.

If a signal generator is not available, it should be possible in south-east England to align the oscillator on the signal from Wrotham. For this purpose a dipole resonating at receiver mid-band (approximately 94 Mc/s) should be connected to the receiver and the tuning capacitor set at approximately half maximum capacitance. The oscillator core should now be adjusted until signals from the Wrotham transmitter are heard. Two signals should be received, an a.m. transmission on 93.8 Mc/s and the f.m. transmission on 91.4 Mc/s. As the feeder unit is designed for f.m. reception the a.m. signal will sound badly distorted. The correct core setting is mid-way between the two points of tune.

It is possible for either or both transmissions to be received at two tuning points, and in the event of this happening, the correct tuning point is that requiring the greater inductance.

When the oscillator has been aligned, the aerial inductance should be adjusted to give maximum output on the a.m. transmission, the frequency of which lies almost at the centre of the band covered by the receiver. To avoid mistuning errors due to a.g.c. action, the a.g.c. lead should be disconnected from C_{25} and earthed. This may not be advisable if the receiver is used in an area near Wrotham and where the voltage across C_{25} exceeds approximately 50 volts without a.g.c. In such circumstances the tuning capacitor can be mistuned to reduce the output across C_{25} to, say 1 volt from the a.m. signal. Alignment can then be carried out as before.

Tuning of the r.f. anode circuit is slightly more difficult because movement of the iron core causes slight mistuning of the oscillator. A.g.c. should be disconnected and the core position adjusted for maximum output from the a.m. transmission measured on a meter connected across C_{25}, the oscillator being returned after each core adjustment to keep the signal accurately in tune. In areas of high field strength there will generally be sufficient output to operate the meter even when the aerial is disconnected; the removal of the aerial is advisable to protect the crystals from possible overload.

It should be noted that at certain positions of the r.f. anode coil dust-iron core, the oscillator may cease to oscillate, due to absorption effects. When the core is correctly positioned, the oscillator will work normally over the whole band.

In order to make adjustments for maximum a.m. rejection, the receiver should be tuned to the a.m. transmission, and the values of R_{15} and R_{18} varied until minimum output is obtained. It should be remembered that the sum of the values of the two resistors should be kept constant at 2.5 kΩ throughout.

Aerials.—The length of the dipole for mid-band frequency is 5 ft overall and a single dipole of this type is generally satisfactory for covering the whole band. The Wrotham transmissions are horizontally polarised and consequently the dipole should be mounted in the horizontal plane. In this position, its polar

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diagram in the horizontal plane is a figure-of-eight, the direction of maximum pick-up being at right angles to the length of the dipole.

With the unbalanced input of the type used in this unit it is generally desirable although not essential, to use a balanced-to-unbalanced coupling at the aerial. This may be constructed quite simply by using a $\lambda/4$ section of feeder connected between the inner of the feeder proper at the aerial and the outer of the feeder as shown in Fig. 7. This arrangement makes the unbalanced feeder appear as a balance feeder to the aerial. It should be noted that the $\lambda/4$ balancing length of feeder is $\lambda/4$ measured in electrical length, and not physical length. The ratio of the physical length to the electrical length is determined by the "velocity factor" of the feeder; for most solid dielectric 70-ohm feeders the ratio is in the region of 0.67. The physical length of the balancing section should thus be approximately 1 ft 8 in.

If additional aerial gain and directivity are required, a reflector and/or directors may be used. For a reflector, the length of the element should be approximately 5 ft 3 in, spaced at a distance of 2 ft 6½ in behind the dipole. If a director is used, a suitable length is 4 ft 9in, spaced at a distance of 13 in. in front of the dipole. For additional directivity a second director, of the same dimensions and spacing may be placed in front of the first. It should be noted that the impedance of the aerial will be reduced appreciably by the presence of such elements, and the position of the aerial coupling coil may need adjustment. This can be done by varying the coil position until maximum output is obtained. It should also be noted that the bandwidth of the aerial decreases as the number of aerial elements increases, and it may be found advisable to use a folded dipole. The impedance of a folded dipole composed of two similar thin elements in free space is 320 ohms approximately; it is especially suitable for use in arrays, where the presence of the other elements lowers its impedance to a convenient value.

Performance.—It is difficult to give precise sensitivity figures for the unit because of the effects of a.g.c., and because the unit does not incorporate a.f. stages from which the usual reference output of 50 mW output could be taken. The sensitivity, however, is such that an input signal of 50 μV at mid-band frequency produces a d.c. output of 1 volt at the discriminator. In terms of a.f. output, 1 volt discriminator d.c. output corresponds to a peak audio output of 0.35 volt at 100 per cent modulation, i.e., 75 kc/s deviation. The gain is progressively reduced for larger input signals and in practice the d.c. output will not exceed 10 volts, with a corresponding peak a.f. output of 3.5 volts. The sensitivity of the receiver falls off by about 6 db at both ends of the band.

The stability of the oscillator has been checked by running the unit for long periods and after the first ten minutes, the drift was not sufficient to be troublesome.

Correction.—In the list of parts in Part 1 the capacitors C_{12} and C_{28} were given as 0.001μF whereas the correct values are 0.01μF. Holes for adjustment of the dust cores in L_8 and L_9 must be drilled in the top of the two i.f. transformer cans.

Phase-angle Ellipse

MOST textbooks which deal with the cathode-ray oscilloscope show a diagram of the ellipse which is obtained when equal voltages of the same frequency but differing in phase are applied to the *x*- and *y*-plates. Most of them also show how the phase difference can be computed from measurements taken from the screen of the tube. Usually a diagram like Fig. 1 is given and it is stated that the phase difference is

$$\theta = \sin^{-1}\frac{A}{B}$$

While this is correct, it is quite difficult to measure A and B with any accuracy because the reference axes shown in Fig. 1 do not normally appear on the tube.

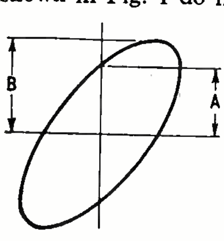

Fig. 1

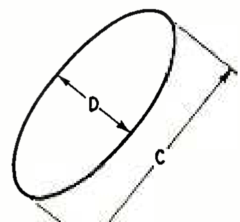

Fig. 2

Fig. 1 shows a method of defining an ellipse by measurements from its centre, while Fig. 2 illustrates a simple way involving only the major and minor axes.

A graticule must be used and its reference centre must coincide with the centre of the ellipse.

It does not appear to be generally known that the phase angle can be computed equally easily from measurements of the major and minor axes of the ellipse. These can be taken off the tube face much more easily and accurately, for they are merely the distances C and D in Fig. 2. The phase angle is then

$$\theta = 2\tan^{-1}\frac{D}{C}$$

and for small angles this reduces to $\theta \approx 2$ D/C radians or 114.6 D/C degrees.

The formula is simply derived. The *x*-deflection is proportional to $\sin \omega t$, say, and the *y*-deflection to $\sin(\omega t + \theta)$. The distance z of any point on the ellipse from the centre is

$$z = \sqrt{[\sin^2 \omega t + \sin^2(\omega t + \theta)]}$$

By differentiating and equating to zero it can be found that the values $\omega t = -\theta/2$ and $\omega t = \pi/2 - \theta/2$ correspond to z_{min} and z_{max}, which are each respectively one-half of the minor and major axes, D and C, of the ellipse. For these values of ωt

$$z_{min} = \sqrt{2}\sin\theta/2$$

$$z_{max} = \sqrt{2}\cos\theta/2$$

$$\text{whence } \frac{z_{min}}{z_{max}} = \frac{D}{C} = \tan\frac{\theta}{2}$$

W. T. C.

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European V.H.F. Broadcasting

Summary of the Recent Stockholm Conference

THE use of very high frequencies for broadcasting and television on any appreciable scale in Europe being a comparatively recent development the Stockholm Conference, to which brief reference was made last month, was faced with many new problems. Before dealing briefly with these problems and their solution, some reference should be made to the genesis of the Conference.

At a meeting of Study Group XI of the International Radio Consultative Committee (C.C.I.R.) held in London in May, 1950, to discuss questions of television technique, the Swedish representative suggested that the time was rapidly approaching when the European countries should draw up a plan for the assignment of frequencies to their v.h.f. sound and television broadcasting stations. A number of other countries shared this opinion—believing, no doubt, that the time to make a frequency plan is before there are large numbers of working stations to complicate the problem—and in due course Sweden invited the countries of the European Broadcasting Area to a conference in Stockholm on 28th May for the assignment to European television and broadcasting services of frequencies in the broadcasting bands between 41 and 216 Mc/s. The bands in question are 41-68Mc/s (Band I), 87.5-100 Mc/s (Band II) and 174-216 Mc/s (Band III).

The Conference finished on the 30th June after preparing an agreement with which are associated three plans, one for each band. The administrations of 31 countries were represented and the agreement was signed on behalf of 21 of them, the non-signatories being Portugal, the U.S.S.R., and eight other Eastern European countries. The plans will come into force on the 1st July, 1953.

Basic Considerations

With one exception the Stockholm plans are based on the use of Bands I and III for television and Band II for sound broadcasting; the exception being that the U.S.S.R. and other Eastern European countries may use the 57-68 Mc/s portion of Band I for sound broadcasting. The Conference's basic task was, of course, to assign the frequencies in these bands so that each station could operate without interference from any of the other stations in the plan. Before this could be tackled it was necessary to decide:—

(*a*) what propagation data should be used to estimate the field strength of the interfering signal that the stations would lay down at various distances;

(*b*) what ratio of wanted to unwanted signal (called the protection ratio) should be used as a basis for planning (i) when the unwanted signal is on the same frequency as the wanted one, (ii) when it is on an adjacent frequency;

(*c*) what value of field strength of the wanted signal should be protected; and

(*d*) what should be the separation between adjacent frequencies.

Question (*c*) may require some explanation. Having decided what are reasonable values for the protection ratios it is necessary to decide which field strength contour of the wanted signal they should be related to. This is normally of the order of the lowest field strength that will give a useful signal, since if a higher value is selected the effective service area may be reduced by interference, while if a lower one is chosen the distance that must separate the wanted and unwanted stations is increased unnecessarily, and the number of stations that can be accommodated within the available frequency bands therefore reduced

These questions are common to all frequency assignment planning but they created some special problems for the Stockholm Conference.

Polarization and Propagation

The study group of the C.C.I.R. concerned with tropospheric propagation met in Stockholm immediately before the Conference and prepared a series of curves showing, for a given radiated power, the field strength exceeded for specified percentages of the time as a function of distance. These curves, which were based largely on experimental data obtained in the United Kindom by the D.S.I.R., B.B.C. and G.P.O., were adopted by the Conference.

The United Kingdom had proposed, as a result of studies made by the B.B.C., that when an interfering transmission was polarized at right angles to a wanted transmission an additional protection of 10 db could be assumed. Although this proposal was not formally adopted it was generally accepted and used in the preparation of plans.

The answers to questions (*b*), (*c*) and (*d*) for sound broadcasting depend on the type of modulation employed and to some extent on the characteristics of the receivers used. All countries announced their intention to use f.m. with the exception of Belgium and the United Kingdom, who reserved the right to decide later whether to use a.m. or f.m. There was general agreement to a maximum modulation frequency of 15 kc/s and for f.m. systems a maximum deviation of ±75 kc/s and a pre-emphasis time constant of 50 microseconds were generally favoured.

The Conference considered the questions in relation to both systems of modulation and reached the conclusions tabulated below.

It is worth recording that the figures are in complete agreement with those put forward by the United

	Ratio of wanted to unwanted signal for transmissions on the same frequency*	Field-strength to be protected
A.M.	30db†	1500μV/metre
F.M.	20db	250μV/metre

* This ratio to be equalled or exceeded for 99% of the time.

† Assumes that the frequency difference between wanted and unwanted signals is less than 250 c/s.

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Kingdom which had been derived from extensive tests made by the B.B.C. and G.P.O.

There was no general agreement on the protection ratios required when the unwanted signal was on a frequency different from that of the wanted signal. In this case the ratios are largely dependent on receiver characteristics and there was some divergence of opinion on what limits could be economically realized in commercial sets. For similar reasons there were different views on what the frequency spacing between adjacent channels should be, and agreement on a standard spacing was not reached. It was, in fact, considered unnecessary to adopt any standard channel spacing but in making a plan to provide the protection ratio appropriate to the frequency separation of wanted and unwanted signals for the type of receiver to be used.

Problems of Television Channel Widths

The problem in Bands I and III was complicated enormously by the fact that there are in Western Europe three different television standards; the British 405-line system, the 625-line system used by most Continental countries, and the French 819 lines, using channel bandwidths of 5, 7 and 13.15 Mc/s respectively. The problem was still further complicated by the proposals of some Eastern European countries to use 625 lines with an 8-Mc/s channel bandwidth and parts of Band I for sound broadcasting; by the Belgian proposal to use the 819-line and the 625-line systems in a 7-Mc/s channel bandwith with a.m. sound for both systems; and by the French plan to use a *tête-bêche** channelling system.

The Conference therefore had to consider both the field-strengths to be protected for each system and the protection ratios required by each system for interfering transmissions of different types, both sound and vision, for a wide range of carrier frequency spacing of wanted and unwanted signals. It was very considerably helped in studying these problems by the fact that Study Group XI (Television) of the C.C.I.R. had met in Stockholm immediately before the Conference and had already explored the ground very thoroughly.

It is not possible to give the findings of this Study Group in detail but the following were among the more important recommendations made:

For television transmissions on the same channel with carrier frequency spacings of less than 100 c/s a protection ratio of 45 db is necessary for at least 90 per cent and preferably 99 per cent of the time. When the carrier frequencies of the transmissions are "offset" by approximately $\frac{1}{2}$ or $\frac{2}{3}$ of the line frequency the protection ratio can be reduced to 27 db and 30 db respectively. The protection ratio required against the adjacent channel sound carrier was −6 db. It was, however, agreed that these ratios should be increased by some 5-6 db when the interfering signal was an a.m. sound transmission.

This Study Group made no recommendations on the field-strengths to be protected and the Conference was unable to reach any general agreement on this but it was accepted that for the 405-line system figures of 100 μV/m and 300 μV/m for Bands I and III, respectively, should be used, and that for both the 625 and 819 lines 500 μV/m and 1000 μV/m for Bands I and III, respectively, should apply. The U.S.S.R. and certain other Eastern European countries maintained a figure of 1000 μV/m for both bands.

In applying the conclusions of the Conference's Technical Committee to the preparation of the plans individual cases were considered on their merits and, in order to meet countries' requirements as fully as possible, some lowering of technical standards was sometimes made where it was acceptable to the countries concerned. Thus, while it was generally agreed that the distances between stations should be sufficient to ensure that the desired protection from interference was obtained for 99 per cent of the time there are some cases where by mutual agreement the actual distances in the plan are less than this. Considerable use was made of the possibilities of offset carrier operation and different polarizations to increase the number of workable assignments.

The plan for Band I provides for 185 television stations in Europe. So far as the United Kingdom is concerned we are allocated the five frequencies at present in use on which twelve stations may operate. It also includes 151 assignments for sound broadcasting stations in the U.S.S.R. and other Eastern European countries.

The plan for Band II includes nearly 2,000 assignments for sound broadcasting stations. As it has not yet been decided whether a.m. or f.m. will be used for v.h.f. sound broadcasting in the U.K., the plan includes, as alternatives, two sets of assignments for this country—one, providing for 109 a.m. stations, and the other, 79 f.m. transmitters. Both would provide for substantially complete coverage of the country with three programmes.

The plan for Band III includes 383 television assignments—28 of them for the United Kingdom.

Since the precise way in which v.h.f. sound and television broadcasting services will be developed in this country in Bands II and III has not yet been decided, the British delegation, in signing the agreement, entered a reservation which makes the signature effective only for Band I.

Permitted Variations of the Plans

V.H.F. sound and television broadcasting are such relatively new developments that many assignments in the Stockholm plans are tentative and although the plans as a whole are due to be reviewed not later than 1st July, 1957, there was a general feeling at the Conference that there should be a good measure of flexibility in the meantime. Accordingly the Agreement includes a clause which allows countries to change the powers, frequencies or other technical characteristics of their stations after obtaining the agreement of other countries likely to be affected by the change.

Although the Atlantic City Radio Regulations allocate Bands I, II and III for broadcasting in Europe generally, they include certain special provisions for individual European countries. Thus in the United Kingdom 95-100 Mc/s may be used for point-to-point and land-mobile communication services, 174-200 Mc/s for point-to-point communication and 200-216 Mc/s for aeronautical radio-navigation; non-broadcasting services are being operated in these bands at the present time. On the other hand France, whose 819-line television system requires a bandwidth of some 13 Mc/s per channel, is entitled to use the band 162-174 Mc/s for broadcasting as well as Band III, and the Stockholm plans include some 13 assignments for French television in this "extension band."

* In the "tête-bêche" arrangement, the full sidebands of adjacent channel transmissions substantially overlap and some economy in frequency usage is thus effected.

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Projection Television
versus
Direct Viewing

[A note by R. C. Heath, chief electronic engineer of Peto Scott, who make both kinds of television receivers.]

IT is where the range of picture sizes that can be produced by either system overlap that direct-viewing and projection television receivers come into direct competition. It is felt that at the present stage of development there is no one technical feature which is so fundamentally good or bad in either system as to dictate which is superior and it must largely depend upon the taste of the individual viewer as to the type of receiver which gives him the most pleasing picture presentation.

Back projection pictures have the advantage of being completely flat and free from serious reflections of light from the screen. A reasonable standard of definition is obtained and the whole effect produced appears to be a well contrasted but soft and restful picture to watch. Although projection tubes and direct viewing tubes have a similar duration of life, eventually they will have to be replaced before the receiver as a whole becomes unusable due to deterioration by age. When replacing a projection tube there is marked advantage as it is much cheaper than a direct viewing tube giving an equivalent picture size.

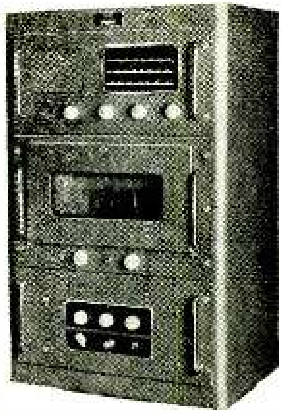
The limitations of back projection appear to be mainly restricted viewing angle, especially in the horizontal direction, and that the controls require a little more skill to adjust the receiver to give the best possible results. Also, the viewing distance is more critical than with a similar sized direct viewing picture. Although the electronic equipment itself can be quite compact, as the cabinet has to accommodate the optical system and the appropriate throw distance for the picture, on the whole back projection sets tend to be rather larger than direct viewing sets, which is of course quite an important consideration for owners of small houses.

Modern direct viewing receivers are capable of showing very bright pictures, which undoubtedly impress the viewer initially, but may not suit all tastes for prolonged viewing. The receivers are capable of producing the full quality of definition transmitted by the B.B.C. without any limitations due to the screen texture or optical resolving power. With the use of "wide angle" tubes the direct viewing receiver, even for 17-inch pictures, may be made a very compact unit, and in fact it is possible to house a 17-inch rectangular tube and chassis in a cabinet a little larger than the standard 12-inch table model. One is not greatly restricted in the viewing angle, and the viewing distance is not critical, providing the viewer is not consciously worried by line structure.

The limitations of the receiver appear to be screen curvature, although this effect has been much reduced by the introduction of approximately flat-faced tubes, and owing to the glass surface of the viewing screen there is a possibility of reflections from incident light, which can be most disturbing and the receiver has to be orientated to prevent this effect. The contrast of the picture between black and white depends on the amount of incident light falling on the grey screen of the tube, but this can be improved by the use of neutral filters, but of course these filters have polished surfaces and there is still a possibility of reflection from the filter surface, as from the face of the tube as mentioned above.

All other features of a quality television picture are equal for either back projection or direct viewing. That is to say, equally good picture linearity, interference suppression, interlace, etc., may be obtained.

Therefore, one may draw the conclusion that, as the development of the two techniques stand to-day, and providing one is not influenced by cathode-ray replacement cost, the choice of a receiver depends greatly on the type of picture presentation which appeals to the individual viewer. There seems little doubt that in another decade or so all television techniques for producing medium and large-sized pictures will be some form of projection, but this is very much in the future.



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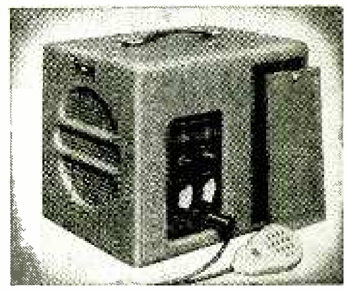

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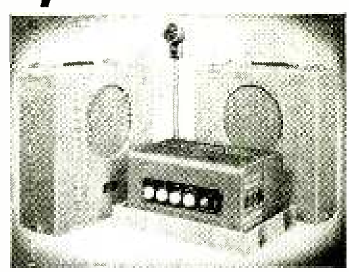

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RANDOM RADIATIONS

By "DIALLIST"

Good Show!

THIS YEAR'S RADIO SHOW was a good one, I thought. It was bright, attractive to the eye and full of interesting things. Excellent work was done by the control room in piping an almost continuous supply of sound and television programmes to the stands. It seemed to me, too, that most of the stands were better provided than they used to be with men capable of answering technical questions concerning the wares displayed. One incident on the pre-view day must go on record. Over the main entrance was a large notice to the effect that though the show was in theory open only to those bearing special tickets, members of the public prepared to pay 5s (double the fee for other days) would be admitted. Some, although surprisingly few, thought it worth while. Others wandered round the outside of the great building until they came to wide open doors (marked on the official map as exits) with never a soul guarding them. Through these the enterprising marched unchallenged. I heard one young man remark to the pretty little thing he was escorting: "This looks like being the best free fivebobsworth that's come our way!"

Is it Too Big?

How many, I wonder, will agree with an opinion that I formed on the pre-view day and retained unaltered in the course of subsequent visits? This was (and is) that the Radio Show has become too big. It is natural, I suppose, that as the radio industry expands, the exhibition of its products should grow larger and larger year by year. But it seems to me that it is now so enormous that anyone who tries to "do" the whole Show is bound to suffer from a severe attack of mental indigestion, unless he can manage to make several visits to it. I'm not at all sure that the best solution wouldn't be to group the stands in two separate and distinct areas of the hall. One would be devoted strictly to domestic broadcast receiving gear; the other, to electronic apparatus falling into other categories.

Navigational Aids Needed

It is just possible that the show *seems* larger than it is because it is now spread wide over the immense area of Earls Court, instead of being more compactly housed at Olympia. Yes, I really believe there's something in that. Not only is Earls Court very big; it is also (or so it seems to me) much more difficult to find one's way about there. There aren't so many landmarks to guide one's wanderings and the sign-posting is far from being as good as it might be. Here's a suggestion for an improvement. Name the "streets" (or avenues) in which the stands are placed after men famous for the parts they played in radio and television development—Clerk Maxwell, Hertz, Lodge, Marconi, de Forest, Baird, and so on. Let the names of the "streets" be displayed prominently at either end and at frequent intersections; every stand plainly numbered; and signposts at many intersections indicating the stands contained in the streets they serve and the restaurants, exits and so on to which each of these leads. It would be a whole lot easier than it is now to locate, say, Supermellow Radio, if you knew that its address was 17, Free Grid Avenue.

Resistor Colour Coding

SEVERAL READERS, to whom my best thanks, have been kind enough to send me "problem" colour-coded resistors. The subject of colour-coding was fully dealt with by D. F. Urquhart in the May, 1952, number of *Wireless World*. The system is now so widely adopted—by the Services, the R.I.C. and most, if not all, of the radio and electronic manufacturers' associations—that, whether we like it or not, we must regard it as having come to stay. Its weakest point is that a colour-band painted over another colour may be difficult to identify, no matter how good one's sight is. All of this will, no doubt, be set right in time. There is no doubt about the value of the coding system to those whom constant practice enables to read off values at a glance. But many of us do constructional work only at intervals and I know how we'd bless resistor manufacturers if they would also mark them in plain figures for our benefit.

A Diehard

WHILE TURNING OUT one of my workshop cupboards a week or two ago I came across an ancient Varley "dry" accumulator. It had certainly been there since the days before the war and it seemed that it must be ripe—over-ripe—for the dustbin. You can't see the innards of these things, for they have opaque cases. There had, however, been no horrid oozing from the vent and the terminals were clean and uncorroded. Might as well see, thought I, if there is life in the old dog yet. After giving it all the water it would take I put it on very slow charge (0.25A). Twenty-four hours later it was showing an e.m.f. of 1.9 volts under a load of 0.5A. Since then it has been charged and discharged

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three times, "drinking" a total of about 2½ fluid ounces of water during the charging periods. I don't know its capacity, for the label has disappeared; but I put it at 10 ampere-hours. It is now showing well over 2 volts on open circuit after charging and 2 volts under a 0.45A load for an average of 18 hours.

Nasty Mess!

TALKING ABOUT ACCUMULATORS, have you ever seen the devastation that can be caused in a battery set by the disintegration of the plates of its mass-plate filament battery? I hadn't realized how serious it could be till I spent an evening with a friend shortly before this was written. At nine o'clock he switched on his battery set for the news. Nothing could have been more silent. "Can't be the accumulator," he said, "for I put in a freshly charged one yesterday." It *was* the accumulator; but not in the way he meant. When we took off the back of the set a queer sight met our eyes. All over the exposed metal parts were tell-tale green patches showing that dilute sulphuric acid had been at work. The vent of the accumulator had been stopped with a plug of glass wool and this had been blown out. The negative plate was in ruins. Between it and the positive plate lay a black mass of material, which had caused an internal short. When the short occurred the cell must have, so to speak, boiled over, flinging acid all over the interior of the set. We did what we could to prevent further corrosive action by using paint brushes to apply a strong solution of washing soda in water. I'm afraid, though, that the set is beyond first aid. The valves and some of the covered-in components have probably survived; but almost the whole of the wiring will have to be re-done. And, even if they seem sound now, not a few of the coils, resistors and so on would be liable to break down under the delayed effects of acid contamination, were they used again.

"Wireless World" Diary

IT IS HOPED the *W.W.* Diary for 1953 will be available from stationers and bookstalls towards the end of October. In addition to the diary pages—giving a week at an opening—there are 80 pages of reference matter including valve base tables, abacs, formulæ and circuits. In rexine the price (including purchase tax) is 4s 7d and in leather 6s 1½d. The prices for overseas readers are 3s 9d and 5s, respectively.

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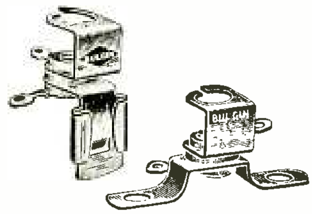

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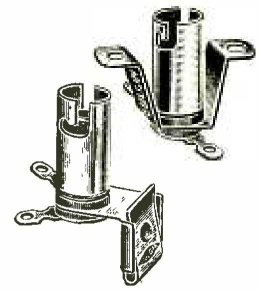

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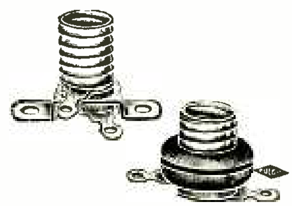

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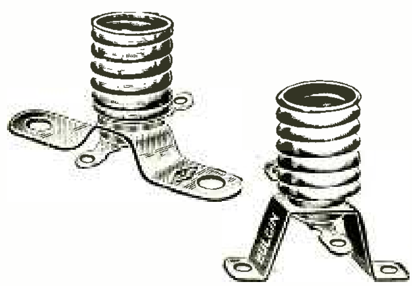

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Physics and Philology

I WONDER if any of you nuclear physicists who dabble in sub-atomic particles can tell me how many known members there are at the present date of the great and growing "on" family? The electron, the proton and several other members of this family or club are well known to me, but nowadays new candidates seem to be put up and elected to membership at a rate almost equalling that attained within the chromium-plated portals of the "Hollywood ex-Husbands' Club."

In fact, I must confess that if the Editor were suddenly to call upon me to name all the present members of the "on" family I should have to hang my head in shame and return my *Wireless World* tie to him; at a risk of being adjudged guilty of *lèse-majesté*, I have sometimes thought that the Editor might have to forfeit his own *W.W.* tie if asked to pass the same test.

"Elementary, my dear Watson."

A writer in one of our photographic journals states that there are now a dozen members of the "on" club and seven would-be members on the waiting list having their credentials examined. Now, I never believe all I read (not even if it is written by myself) without very strong corroboration, and it is this or your earnest disputations about the matter that I am now seeking.

While on the subject, I should like to know, too, the real reason why the names of all the members of this family end in "on." The answer *seems* simple, namely, that it is because the name of the patriarch of the family, the electron, happens to end in "on." But we must not jump to hasty conclusions.

I have not forgotten that I, and many others more learned than me, once inclined to the view that the great "tron" family, to which belong the magnetron, the klystron and such great names as these, also came from the latter part of the word "electron." But, being far from sure about it, I put the question to you in these columns. The result was that an infinitely patient "Elementary, my dear Watson," coming from the Parnassian slopes of Witley (*W.W.*, April 1947, p. 150), showed me that I had been led astray by the red herring of a too-obvious clue.

It Isn't Cricket

A COUPLE of months ago I complained of the increasing misuse of the word "electronic" which threatens to become as much a fetish word as "dyne" did in the 'twenties. It was, in fact, so abused that it became a synonym for "circuit" and completely lost its original meaning.

A reader points out to me that the abuse of the word "electronic" is far more extensive than I had first thought, as he sends me an advertisement from an American magazine describing an electronic golf ball. Now, my motto has always been *audi alteram partem*, and I must, therefore, place it on record that, on the authority of a technical expert, I believe the use of the word has some justification in this case.

The expert points out to me that Scotland is the H.Q. of golf and that he can scarcely believe that the scientifically minded and thrifty folk up there would have overlooked the possibility of using modern technical principles for recovering and annexing other people's lost golf balls. It would be so easy to manufacture golf balls with a minute amount of radioactive material in them so that they could, when lost, be easily located with a Geiger counter in the still watches of the night.

If my expert friend's surmise be true, it would be only natural for the canny Scots to carry the idea across the Atlantic to the land where there are so many more players and, therefore, so many more potential losers of balls. I can only say that I have enough faith in my friend's knowledge of human nature to be writing these words from Scotland where, complete with kilt and Geiger counter, I am endeavouring to obtain evidence for the justification of this particular use of the word electronic.

Quite apart from any question of electronic golf balls, I have long thought that, with the present rapid development of guided-missile technique, we are on the eve of a revolution in the playing of ball games. It is not hard to visualize that by the time A.D. 2000 dawns such progress will have been made in the miniaturization of radio control gear that our children will witness an unscrupulous and unsportsmanlike attempt being made by England to recover the Ashes from Australia by means of guided cricket balls, and it will be of little use the old fogeys of that day shaking their heads and saying "It isn't cricket."

Cavalcade of Coronation Radio

ALL of us who can proudly claim to have read *W.W.* with Micawber-like persistence since the first number appeared can also claim to have lived in six reigns. After next June we shall also be able to say that we have known four coronation days. It is true, of course, that forty-one years ago there may have been a handful of readers of the first number (April, 1911) who could also truthfully boast of having lived in six reigns and, if they survived the shock of the first three numbers, could claim to have known not four but five coronation days. If this is not clear to you it might be worth your while to consult a solicitor to see if there is any chance of your getting a refund of the money your parents spent on your education.

However, my real reason for talking of coronations was that I wanted to ask if any of you can say that to your personal knowledge radio has been used officially or unofficially in connection with all the coronations of the century. I am inclined to think it has played its part *officially* on all the three days concerned.

Everybody knows that broadcasting and television were used in 1937. In 1911, although there was no broadcasting, the receipt of news by ships at sea was commonplace. But was news of the 1902 coronation transmitted by wireless?

In the case of ships of the Royal Navy, I think it can hardly be questioned that radio was used for a special transmission. By immemorial custom the moment when the Crown is placed on the Sovereign's head is signalled from the Abbey so that a salute of guns can be fired at all points where Royal salutes are customarily made in this manner. Would not wireless have been used to signal this moment to all H.M. ships outside the range of visible or audible signals?

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