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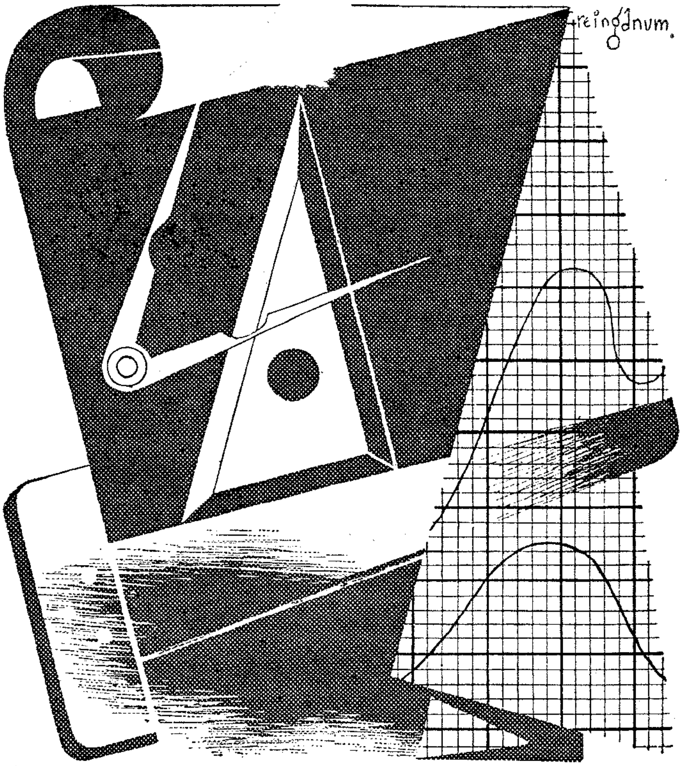

Wireless World
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Against Wired Broadcasting

Explaining Our Attitude

LAST month we stated our reasons for opposing the big-scale introduction of wired broadcasting and, since then, have received a large number of letters on the subject. Naturally, most wireless men object to the introduction of a system that threatens the expansion of their technique, and so support our attitude. But a surprisingly large number of readers feel that the technical arguments for the wire are so strong that it should be given a trial. That might come later, but we strongly contend that the immediate post-war period is not the appropriate time to make such a sweeping change. It seems necessary to amplify the reasons already given for this view.

In explaining the attitude of *Wireless World* it would be well to re-state, as concisely as possible, our main grounds for objection. Politically, an isolationist wired system is wrong for a post-war world of which the future is generally thought to depend on international co-operation; also a wired system is, under post-war conditions, too dangerous a weapon to place ready-made in the hands of a possible enemy of our liberties. Remember that Hitler came to power by exploiting mass psychology through the loud speaker, consolidated his power through broadcasting, and then introduced the *Volksempfänger,* which gave him some of the advantages of a watertight distribution system for canalising public opinion. Economically, wireless is not yet developed to such an extent that it can afford to dispense with the stimulus and the financial contributions of radiated broadcasting. It was stated only a few weeks ago that broadcast receivers accounted for 80 per cent. of the output of the pre-war British wireless industry, leaving only 20 per cent. for transmitters and general communication equipment. Any country adopting the wire would fail to keep pace with those retaining radiating systems.

Letters expressing contrary views are published elsewhere in this issue, and we can best substantiate our opinions by replying to specific points.

"There has never been any suggestion that the household set should be 'purged' or that a ban should be placed on foreign listening," says a reader. Exactly; but if the G.P.O. undertook broadcast distribution over the telephone wires one can imagine that the extent of radio listening would soon become negligible, without any need for a ban. To boost its new venture the G.P.O. would have at its command the B.B.C. microphone, the most powerful instrument of publicity in the country, and the great mass of the public could hardly fail to succumb. The B.B.C. would probably be only too willing to lend itself to the campaign. Indeed, certain sections of the Corporation, remembering with acute discomfort the embarrassment caused by competitive broadcasting from Radio Normandie and Luxembourg, would welcome anything that removed a threat to its monopoly. Incidentally, we would hazard a guess that this broadcasting to Britain from abroad, which also tended to cut across the P.M.G.'s communication monopoly, was responsible for first inclining the official mind towards wired broadcasting.

International Broadcasting

Several readers suggest that there is no essential difference between the present (or even the pre-war) Government control of broadcasting and the control that might be exercised over a wire system. So far as internal broadcasting is concerned, that is true, but, from the international point of view there is all the difference in the world between a watertight wired system and a radiating system, where a turn of the dial can bring in outside opinions not subject to internal control.

Other readers, while admitting our statement that the pre-war public judged its broadcast receivers by their ability to receive distant stations, deny that it made any real use of that facility. That, also, is true, but it is beside the point. What is described as the "magic of distance" started the public interest in radio, and wired broadcasting would be too prosaic to sustain that interest.

The public did not listen consistently to foreign stations because real international broadcasting had hardly begun; it has not yet achieved, as a world unifying force, even a small fraction of what we hope and think it eventually will.

USE OF VALVES

What is "Good Practice"?

By J. R. HUGHES, A.M.I.E.E.,
(British Radio Valve Manufacturers' Association)

THE recently issued War Emergency British Standard B.S. 1106 sets out a code of good practice in respect of the use of radio valves; by due regard to its provisions optimum operating conditions and good valve life can be ensured. This article, which is a survey of some of the basic theoretical considerations which form the justification for the Code of Practice, explains the reasons for the recommendations made in the Code.

Only a small part of the Code of Practice deals with the more general and perhaps more obvious aspects of valve use. The major part is devoted to information and advice on specific points, much of which appears not to be generally known or for which the reasons are imperfectly understood.

Valve Ratings. — The manufacturers' published data includes a number of "Ratings" which must be considered as limiting values. It must not be assumed that any one of them may be exceeded because others are not approached. To take as an example a rectifier, the ratings would normally include the maximum input voltage and the maximum DC output current. The use of an input voltage lower than the rated maximum cannot justify a DC output current higher than the rated maximum.

A radio valve is a complicated structure, the design of which must always be a compromise between a number of physical, mechanical and chemical considerations. For instance, the design features which determine the input voltage rating of a rectifier are not the same as those which determine the output current rating. The permissible maximum current may be limited by anode dissipation or by cathode emission or both, whilst the permissible maximum input voltage may be limited by inter-electrode spacing, as well as by the anode dissipation. Evidently then, the different ratings of the valve are interdependent to some degree, but certainly not interchangeable in any simple manner.

Many valves include among their ratings the maximum frequency of operation. A variety of different factors may call for this rating, such as the eddy-current heating of the valve electrodes and connections, the dielectric loss heating of the glass seal through which the electrode connections pass, the loss of valve efficiency due to transit time (i.e., the time taken by an electron to travel from the cathode to the anode), or, in the case of a mercury vapour rectifier, the time necessary for the ionised vapour to de-ionise. It will be evident that it may be possible in some cases to raise the frequency of operation above the rated maximum if other ratings of the valve are appropriately reduced, whereas in other cases the frequency limit will be an absolute limit which may not be exceeded in any circumstances. Accordingly, the advice of the manufacturer should always be taken when contemplating the use of a valve at a frequency in excess of the rating.

Heater Voltages and Currents. —The Code of Practice stipulates that in general the heater voltage should not vary more than 7 per cent. each way from the rated value and that in some cases the regulation must be even closer. Moreover, emphasis is laid on the lesser-known requirement that "low heater voltages are as much to be avoided as high voltages. . . ."

In a valve the emitted electrons collect round the cathode to form a space charge. This space charge acts as a kind of reservoir from which the electrons constituting the space current of the valve are drawn. In practice the valve will be designed so that the space current (which is made up of the anode current and the screen currents if any) will be far below the total possible cathode emission.

The cathode emission, however, is a high-order function of the cathode temperature, which in its turn is a function of the heater voltage. Thus a comparatively small drop in the voltage gives rise to a considerable drop in the cathode emission.

If the valve is, for example, an output valve, the total cathode emission under the reduced temperature conditions may be insufficient to maintain the anode current, and in this event the grid voltage/anode current characteristic will not be linear and distortion will result. In the case of a rectifier, the consequences of too low a voltage are somewhat different but no less serious. Here the decrease of emission will give rise to an increased voltage drop across the valve and this will raise the power dissipated in the valve. The point is considered at greater length later in this article, but it can be said that one consequence of this increased dissipation may be the release of residual gas from the electrodes, and this in turn will result in a still further decrease in emission. Thus a vicious circle is established which will ultimately destroy the valve or its associated equipment. Even if the normal anode current of the valve is fairly small and the total emission is adequate to maintain the anode current, the operation of the cathode at too low a temperature is still undesirable, for another reason.

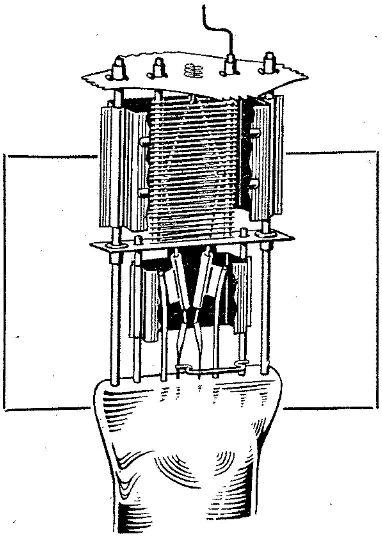
It should be appreciated that the condition of the cathode coating is largely determined by the processing which takes place in manufacture and that this processing is designed to distribute the active element through the thickness of the coating and in its surface. The maintenance of the emission during the useful life of the valve is dependent upon the surface of the coating being continually replenished by active material migrating to the surface. This migration is dependent upon temperature, and the operation of the cathode at too low a temperature may result in its rapid deactivation and the consequent shortening of the valve life.

On the other hand, it should not be supposed that the main risk arising from the use of too high a voltage is that the heater may burn out. If the cathode is operated at an unnecessarily high temperature, excessive evaporation (sublimation) of the emissive coating will take place. Not only does this shorten the life of the cathode coating but it results in excessive deposition of the active material upon the grid and other electrodes. Some of the undesirable consequences of such deposition are considered more fully later in this article, particularly in relation to grid emission.

A further point which is often overlooked is the undesirability of connecting valve heaters in series, unless they have been specially designed for this purpose, as, for example, in the case of AC/DC valves. Normally the manufacturer's data will make clear whether a valve is designed for constant voltage or constant current operation, but in cases of doubt it is wise to make specific enquiries of the manufacturer if series operation is desired. If several valves designed for constant voltage operation are connected in series (thus giving the same value of current through all the heaters), and if one should have a resistance slightly greater than the others, the power dissipated in that one heater will be greater. The heater material has a large positive resistance/temperature coefficient, and thus the resistance and hence the temperature, of the heater, which is already running hotter than the others, will rise further still. In this way a small percentage change in the supply voltage can result in a considerably larger percentage change in the voltage across one of the heaters which are connected in series across the supply.

Mounting. — The Code of Practice recommends very strongly that valves should be mounted vertically with the base downwards. It is a not uncommon practice to squeeze valves into odd corners by mounting them out of the vertical, and it is also true that in many cases no apparent harm results. In the case of mercury vapour rectifiers, no exception to the recommendation for vertical mounting is admissible since it is essential that liquid mercury should be prevented from collecting on the electrodes or on the upper portions of the bulb. Even with other valve types mounting out of the vertical is not to be recommended; partly on the grounds of heat distribution, partly because of the risk of electrodes becoming displaced and so causing changes of characteristics, and partly because of the possibility of the valve being more susceptible to vibration and so causing microphonic noise.

Amongst receiving valves, rectifiers or output valves run rather hot and an unequal distribution of the total heat may easily result in part of the valve structure reaching an excessive temperature. One common consequence of running a valve in an inverted position is that the increase in temperature loosens the base.



Part section of a valve employing flat grid structure.

Directly-heated valves with their relatively long and thin filaments are likely to be rather more troublesome so far as electrode sagging is concerned than are indirectly-heated valves where the cathode is of more rigid construction. Valves having a flat grid structure rather than a circular structure may also be more prone to this trouble if the valve is not vertical. In both these cases the difficulty can be minimised by mounting the valve in such a way that the plane of the filament or grid is vertical even if the valve itself is not vertical.

In the case of valves in mobile or portable equipment the arrangement should be such that the valves are vertical when the apparatus is in its usual operating position.

Heater - Cathode Insulation. —Indirectly-heated valves with automatic bias or in cathode-follower or phase splitting circuits, provide some examples of applications calling for an appreciable potential difference between the cathode and the heater. BS.1106 deprecates the use of standard indirectly-heated valves in circuits where this potential difference exceeds 100 volts.

The cathode assembly of an indirectly-heated valve consists of a small metal tube on the outside of which is sprayed the emissive coating and inside which the heater wire is inserted. The insulation between the heater and the metal tube is normally effected by spraying the heater with an alumina cement before insertion. It is a relatively thin coating and undue liberties should not be taken with it. In valves specially designed for operation under conditions where a high potential difference is to be maintained between the heater and the cathode, additional precautions are taken during manufacture both in regard to the insulating material and its subsequent processing.

The insulation resistance between the heater and the cathode is dependent upon the cathode temperature and also upon the potential difference and the sense or polarity of this potential. The capacity between the heater and the cathode, too, is a somewhat erratic quantity since the heater is liable to move within the cathode under the influence of temperature changes. For these reasons the heater-cathode impedance should not be included in radio-frequency circuits where high stability is required.

It is worth bearing in mind that one of the consequences of a potential difference between the cathode and the heater may be the attraction of electrons from the cathode coating to the heater. Since the heater normally has an alternating potential applied to it

Use of Valves—

any electron current between heater and cathode may be modulated by this potential and so cause the introduction of hum. It is preferable, therefore, that any potential difference should maintain the heater negative with respect to the cathode, but it should be appreciated that it is similarly undesirable for the heater to be appreciably negative with respect to the grid.

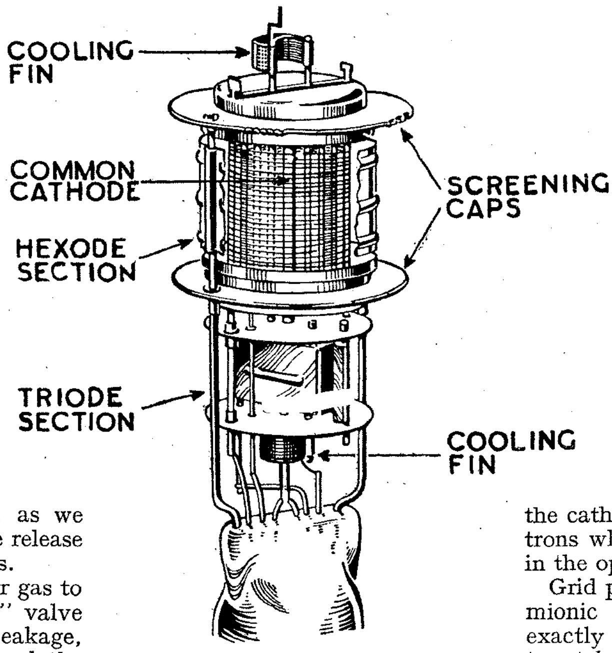
Electrode Temperatures and Gas Release. — With the exception of mercury vapour rectifiers and a few other special valve types the majority of radio valves are "hard," i.e., the bulb contains the minimum of gas. If gas enters the bulb or is freed from within the bulb, the valve is said to have gone "soft" and the effect on the valve's characteristics will be very great indeed. These effects arise from the gas molecules being broken up as the result of collisions between them and the electrons flowing in the normal way from the cathode to the anode. The gas is then said to be ionised and there will be present ions carrying positive or negative charges. Many of the positive ions move to the cathode, and under the influence of the potential existing between the anode and the cathode their velocity when they arrive at the cathode may be sufficient to cause considerable damage by the bombardment of the emissive surface. Apart from this point the mere presence of positive ions in the vicinity of the cathode has the effect of partially neutralising the space charge and the effect of this will be to increase the anode current which, as we shall see, may result in the release of further quantities of gas.

It is very exceptional for gas to be able to enter a "hard" valve as a result of any sort of leakage, but the valve electrodes and the electrode supports are metallic and will contain a certain amount of occluded gas which may be driven from "solution" by an excessive increase of temperature.

This point is taken care of in fixing the valve ratings, and several of the recommendations in the Code of Practice are also based upon it. For instance, the Code emphasises the need to avoid the use of valves ". . . as oscillators or under any other circuit conditions which result in appreciable grid current unless such a requirement is covered by the specification. . . ." The grid current referred to here is, of course, the so-called "grid positive current" formed by a flow of electrons from the cathode to the grid when the instantaneous grid potential is allowed to become positive, or insufficiently negative, with respect to the cathode. This grid current necessarily dissipates power at the grid and the consequent rise in temperature of the grid may result in gas release. Moreover, apart from the temperature rise, the bombardment of the grid by the arriving electrons may also contribute to the release of occluded gas from the grid surface.

Control of Screen Voltage. — The avoidance of gas release is also one of the explanations of another interesting recommendation in BS.1106, which is probably very far from generally known. The recommendation in question reads: "It is desirable that the resistances used in the supply network for voltages on screen grids of multi-electrode valves should be kept as low as possible. Aligned grid valves operating with the screen voltage substantially lower than the anode voltage should derive the screen supply from a potentiometer network. Unaligned grid valves, other than frequency changers, may derive the supply by means of a series resistance."

Small manufacturing variations in the positioning of the electrodes in aligned grid valves result in rather wide variations of screen current from one valve to another. Thus the replacement of a valve in a circuit where the screen supply was derived through a series resistance rather than from a potentiometer might cause the screen voltage to depart greatly from the designed value. This would cause a marked change in performance and the rise in anode current might result in raising the anode temperature to a value at which appreciable gas release takes place. Unaligned grid valves employing a suppressor grid are not normally so critical in this respect.



Illustrating the use of grid cooling fins in a representative triode-hexode frequency changer.

Grid Primary Emission.—In any simple consideration of the operation of a radio valve, it is assumed that the cathode is the sole source of the electron stream. Ideally, the control grid of a valve when operated under "Class A" conditions would neither collect nor lose electrons, and the input resistance of the valve would be infinity. In practice these simple conditions do not hold exactly and the valve electrodes other than the cathode can and do emit electrons which produce irregularities in the operation of the valve.

Grid primary emission is a thermionic emission occurring in exactly the same way as, but fortunately to a much lesser degree than, the thermionic emission from the cathode. It will be appreciated that the valve grids, and more particularly the first or control grid, are heated by thermal radiation from the cathode and that this effect is increased by reflection and radiation from the surfaces of the other electrodes. The resultant grid temperature under certain conditions may be sufficient for appreciable electron emission to take place.

Since grid primary emission is thermionic in character, its prevention or reduction is evidently in part a question of grid cooling. The valve will have been designed in such a manner that, under the conditions permitted by the ratings, the grid or grids will operate at a temperature at which grid primary emission is not troublesome. The cooling of the grid is effected partly by conduction through the grid supports and partly by radiation from the grid or from special cooling fins which may be provided. The efforts of the valve designer will be defeated if a valve is used under conditions where more heat is dissipated on the grid than has been allowed for in design, and this adds further weight to those clauses of the Code of Practice which are concerned with the avoidance of the use of valves under conditions where electrode temperatures may rise unduly.

It was mentioned, earlier in this article, that an excessive cathode temperature could result in the evaporation (sublimation) of the emissive coating of the cathode and its deposition upon the other electrodes of the valve. If a grid becomes contaminated the possibility of primary emission is very greatly increased since the contaminated surface has a greater thermionic emissivity than the original clean metallic surface.

The electrons so emitted will tend to pass to an electrode carrying a more positive potential. In general, this electrode will be the anode, but in any event the stream of electrons leaving the grid will constitute a current which, under the normally accepted convention, flows from the grid to earth through the external path. Such grid current is called "grid negative current" to distinguish it from the "grid positive current" which flows from earth to the grid through the external path whenever the grid potential permits the collection of electrons from the cathode stream.

This flow of grid negative current may set a limit to the resistance which may be connected between the grid concerned and the cathode, since the flow of grid negative current through the external resistance gives rise to a voltage drop which, in the case of a control grid, would offset the bias potential by a value proportional to the external grid resistance. This point explains the necessity for keeping such external resistance as low as possible.

Although it does not occur as a result of grid primary emission, it is necessary to consider here the case of grid negative current arising from another cause, and generally referred to as "gas current." It has been mentioned already that a small residual quantity of gas may be present in the bulb and further gas is liable to be released by an increase in temperature of the valve electrodes. Collision between the electrons from the cathode and gas molecules results in ionisation of some of the latter, which become positively charged and will travel to the grid and other negatively charged surfaces. The arrival of positively charged ions at the grid can be regarded as constituting a grid negative current comparable with the loss of electrons from the grid. It has already been pointed out that the flow of grid negative current offsets the bias potential on the valve to an extent determined by the external resistance of the grid circuit. The reduction of bias voltage increases the anode current and this will raise the temperature of the anode. A vicious circle may therefore be established in which the flow of gas current in the grid circuit causes an increase in temperature of the anode and so results in the release of more gas and consequently in an increase in the gas current itself. This danger of the valve "running away" is obviously dependent upon the external grid resistance and may be avoided by ensuring that this resistance is as small as possible.

These considerations requiring a low external resistance apply equally to all valve grids, but the Code of Practice is more specific in the case of the first or control grid and quotes recommended maxima which should not be exceeded. For voltage amplifying valves, the figures are 1MΩ when automatic bias is used and 0.5MΩ with fixed bias, but in the case of output valves having an anode dissipation of 10 watts or over, these limiting resistances are still further reduced to 0.5MΩ when automatic bias is used and 0.1MΩ with fixed bias. Output valves generally run rather hotter and have a larger grid surface, and for these reasons grid emission is likely to be greater and the external resistance must be correspondingly reduced.

The distinction which is made between the permissible external grid resistances with automatic bias and with fixed bias arises from the fact that, as mentioned already, the flow of gas current offsets the bias potential and, in turn, may bring about a still further increase in gas current. If, however, automatic bias is used, the increase of anode current arising from the offsetting of the bias voltage will cause a compensatory increase of bias voltage. Because of this the conditions are more stable than when fixed bias is used, and the employment of larger values of grid resistance is justified.

(To be concluded.)

AMERICAN AMATEUR'S HANDBOOK

THOUGH the handbook issued annually by the American Radio Relay League is primarily intended for the amateur transmitters that constitute the membership of the League, it has, in the course of the 20 years of its existence, tended to reach an ever-widening public. The 1943 edition, which has expanded to 600 pages, is useful as a source of information on many technical matters besides those primarily affecting the amateur.

The "Radio Amateur's Handbook" may be briefly described as a non-mathematical general textbook of the theory, design and operation of wireless communication equipment, plus much specialised information for the amateur transmitter. Copies are obtainable to order (price 10s. 6d) through the Radio Society of Great Britain, New Ruskin House, Little Russell Street, London, W.C.1.

RECORD TRACKING

Weight Required to Keep the Needle in the Groove

THERE is general agreement among gramophone quality enthusiasts that a light needle pressure is desirable from the point of view of reducing wear on the surface of the groove and thus preserving the low noise level of the newly pressed record. In the early days a weight of 5 oz. was regarded as the minimum which would ensure adequate tracking and prevent the needle from riding up the sides of the groove. This was equivalent to a pressure at the needle point of the order of 30 tons per square inch, and it is not to be wondered at that records showed distinct signs of deterioration after only one playing.

Excessive mass and damping of the moving parts in the older pick-ups was undoubtedly the chief reason for this unsatisfactory state of affairs, and designers soon turned their attention to the problem of lowering the lateral mechanical impedance at the needle point. Miniature needle-armature and moving - coil systems made their appearance, and the average weight required for tracking fell to about 1½ oz. (40 grams).

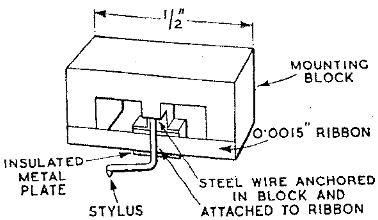


Fig. 1. General construction of frequency-modulation pick-up.

Needle-point impedance is not the only factor determining the downward pressure; the form and fit of the groove and needle profiles are of equal importance. It is for this reason that experiences differ and controversy still centres on the relative merits of light and heavy pick-up heads, spring or counterbalance adjustment of pressure, etc.

A useful contribution to our knowledge of this subject comes from a recent paper by Beers and Sinnett.* In the course of an investigation into the possibility of using a frequency-modulated system of record reproduction the authors developed a miniature variable-capacity pick-up (Fig. 1) and the following facts were given in justification of a choice of 0.003in. for the radius of the sapphire stylus.

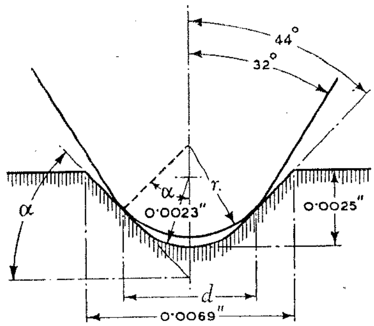


Fig. 2. Section of stylus in record groove showing tracking diameter d and wedging angle α.

"For proper tracking the stylus must have sufficient vertical force exerted upon it to overcome the vertical component of force due to the lateral velocity of the modulated record groove. Calculations have been made which show the vertical forces exerted upon styli of various radii when seated in a standard groove having an 88-deg. included angle, a 0.0023in. radius cutting stylus and a groove width at the top of 0.0069in. In addition to the vertical forces, consideration has also been given to the variations to be expected in pinch effect with different sizes of reproducing styli.

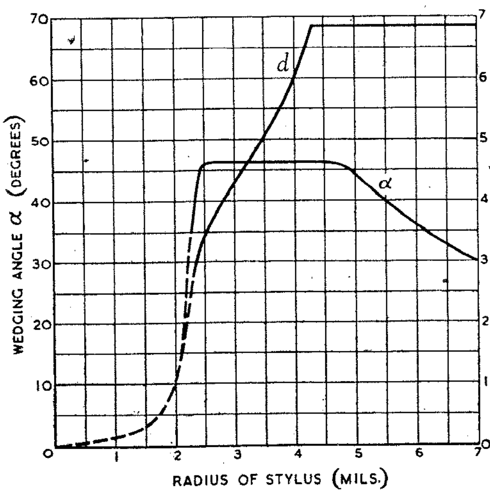
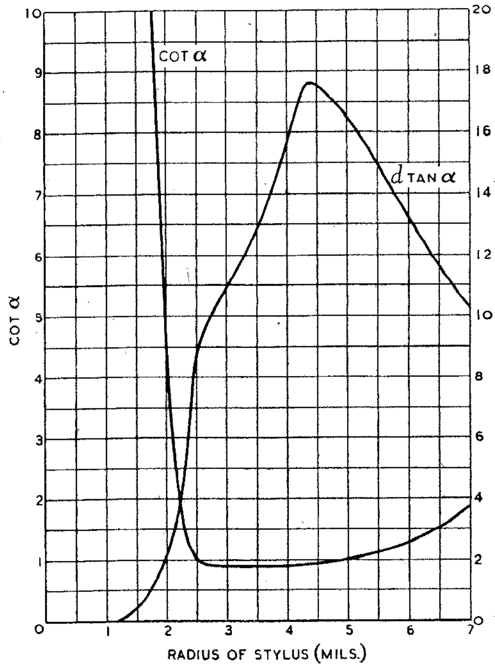


Fig. 3. Variation of tracking diameter and wedging angle with radius of stylus.

Fig. 2 illustrates a stylus seated in a record groove of the above dimensions. Two important factors which change with the diameter of the stylus are: the tracking diameter d and the wedging angle (α). Tracking diameter d has a direct bearing upon both pinch effect and the high-frequency response and should be kept as small as possible. On the other hand, wedging angle α which determines the tendency of the stylus to climb the groove wall, should be made as large as possible for a specified groove. From this it is obvious that a compromise must be made. Fig. 3 shows the variations in d and α with stylus radius; and from observation it can be seen that the stylus radius should not be less than 0.0025in. or greater than 0.0042in. Furthermore, since the curve for angle α is flat from a stylus radius of 0.0025in. to 0.0042in. and the curve for diameter d is rising rapidly over this range it appears desirable, when record-groove variations are considered, to use a stylus radius of about 0.003in. The importance of the tracking diameter d and the wedging angle α is further emphasised by the curves in Fig. 4. This figure shows, in curve form, the two factors cot α and d tan α, which have a direct bearing upon the vertical force due to lateral velocity and pinch effect, respectively. It will be

*"Some Recent Developments in Record Reproducing Systems" by G. L. Beers and C. M. Sinnett. *Proc. I.R.E.* Vol. 31. April 1943.

observed that the curve for cot α approaches infinity for a stylus smaller than 0.0023in. radius, decreases rapidly to about 0.0025in. radius and then remains essentially flat to 0.0042in. At the same time, however, $d \tan \alpha$, the factor governing the pinch effect, increases rapidly from a 0.0023in. radius to a 0.0042in. radius and then decreases. Observation of these two curves provides a further confirmation that a stylus radius of 0.003in. is the best compromise from the standpoint of overall performance.



(Left) Fig. 4. Effect of stylus radius upon factors governing tracking weight and "pinch effect."

In the above equations and those which follow, such factors as the elasticity of record materials and the effective damping of the mechanical system are not included. For this reason the calculated performance characteristics do not provide all the information that might be desired, but they do give a general indication of the performance which can be expected. Expressed mathematically, the conditions for tracking a laterally cut record exist when

$$E_V = Z_L i_L \cot \alpha$$

where

E_V = minimum vertical force acting on the stylus which will ensure proper tracking.

Z_L = impedance of stylus and pick-up moving system in a lateral direction.

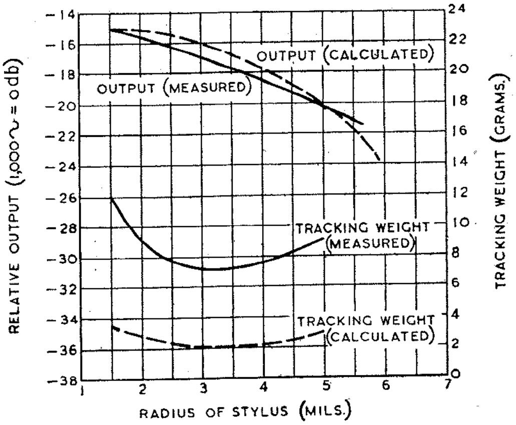
i_L = velocity of recording.

α = angle at which stylus would ride up groove wall.

Utilising the above equation and the previously determined values for the lateral impedance and the curve for angle α, it is possible to calculate the tracking weight required to overcome the vertical force due to lateral velocity as the stylus radius is varied.

As the stylus radius is increased, it is apparent that for a given groove velocity the output to be obtained at high frequencies will decrease. Calculations have been made of the expected loss in high frequencies and ...., Fig. 5, shows the correlation between calculated and measured loss in response at 7,000 cycles as the stylus radius is increased. Also shown in the same figure are calculated and measured curves of the tracking weight required for different styli at 7,000 cycles. It will be noted that while the actual weights required are somewhat higher than the calculated values, because the factors previously mentioned were not included in the calculations, the curve shapes are similar, indicating that the choice of a 0.003in. stylus is a desirable compromise. . . .

Fig. 6 shows the tracking weight required for a frequency-modulation pick-up as compared



(Above) Fig. 5. Calculated and measured tracking weights required by and relative outputs obtained from frequency-modulation pick-up for a wavelength of 0.0053 inch at 7,000 c/s.

with three other types of phonograph pick-ups. Curve (A) is a conventional crystal pick-up having a normal tracking weight of 70 grams. Curve (B) is a transcription-type magnetic pick-up with a normal tracking weight of 45 grams. Curve (C) shows the tracking-weight characteristic of a recently developed crystal pick-up which operates at a normal tracking weight of 28 grams and curve (D) shows the tracking-weight characteristic of the frequency-modulation pick-up normally operated with a tracking weight of 18 grams."

A few remarks on the nature of the "pinch effect" referred to in the foregoing extract may not be out of place here. It arises from the fact that commercial record masters are cut with a chisel-shaped stylus which vibrates with its flat forward face always at right-angles to the mean axis of the record groove. As a result, the width at the top of the groove, and consequently the angle between the walls of the groove, is reduced when the cutter is in lateral motion—the faster it moves sideways the narrower the groove. Maximum groove width in a sine wave is found at the peaks when the lateral motion is momentarily zero, and the minimum width appears half-way between these points as the cutter is passing the mean position with peak lateral

Record Tracking—

velocity. Fig. 7 shows a plan view of a groove of exaggerated amplitude to make this point clear. The sections are enlargements to scale of the groove shape at minimum and maximum width and show the lift imparted to the needle point.

The vertical needle movement passes through a complete cycle between the two peaks (half a wavelength) of the original lateral wave so the frequency of the vertical movement is twice that of the recorded frequency. Obviously the mass of the pick-up head will not permit it to follow this "hill-and-dale" motion, and if the needle suspension is "solid" in a vertical direction, the needle will either plough the groove out to a constant width or remain floating in a mean position, not having time to fall into contact with both walls between the lifts it receives from successive pinches.

The effect is greatest near the centre of the record, where the vertical vibrational velocity may rise to nearly half the lateral velocity at high frequencies. On the other hand, the *amplitudes* involved are small, so that the range of movement required is less than that which must be allowed for in a lateral direction. It is essential, however, that the vibrational impedance to vertical motion should be kept low.

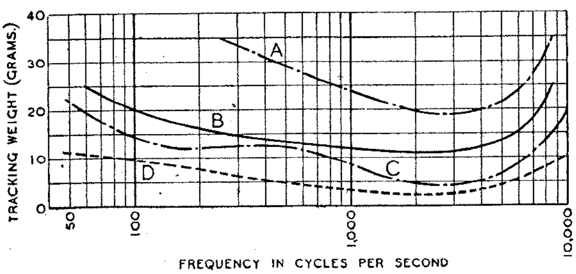


Fig. 6. Comparison of tracking weights required for various pick-ups. (A) Conventional crystal pick-up. (B) Transcription type magnetic pick-up. (C) Special crystal pick-up. (D) Frequency-modulation pick-up.

In the pick-up in Fig. 1 the requisite vertical compliance is provided by bending of the bottom horizontal portion of the steel wire, while the lateral compliance is due partly to bending and partly to torsion of the vertical part to which the ribbon is attached. Changes in capacity between the ribbon and the insulated metal plate are made to vary the frequency of a 6SA7 type electron coupled 30 Mc/s oscillator. A simple resonant circuit is used to convert the oscillator frequency variations to amplitude modulation, the circuit being tuned so that the mean oscillator frequency falls at the 70 per cent. response point on one side of the resonance curve and the output applied to the diode of a 6R7 valve the triode section of which also supplies the first stage of AF amplification.

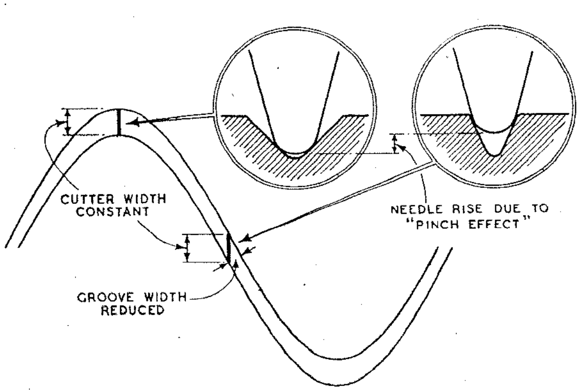


Fig. 7. Illustrating the origin of the "pinch effect."

The change in diode current is proportional to the displacement of the stylus, and in this respect the system described differs fundamentally from other pick-ups which give an output proportional to the RMS velocity of the stylus. As a consequence, the response characteristic taken with a standard gliding tone test record shows a response level up to 500 cycles and then falling steadily at a rate of about 4 db per octave. Treble compensation would be required in place of the usual bass lifting circuit if the system is to be used on existing records, and the authors point out that to obtain the fullest benefit from the system, records "with a high-frequency accentuation characteristic which is comparable to that used in transcriptions" are desirable.

They conclude: "Experimental records of this type have been made. The surface noise obtained from these records with the frequency-modulation reproducing system was reduced to the point where it was not objectionable to the most critical listeners.

Although the calculations and measurements which have been given are confined primarily to 78 revolutions - per - minute records, the same performance advantages are retained in a frequency-modulation reproducing system designed for transcriptions."

PHONETIC ALPHABET

For British and American Forces

THE combining of the British and American Forces in a growing number of theatres of war necessitated the revision of many of the rules of procedure in wireless telegraphy and telephony.

For obvious reasons it is not permissible to publish the various changes introduced. It is, however, possible to give the revised phonetic alphabet now used by the Allied Forces to avoid confusion between similarly sounding letters in telephony.

In the first column are the new code-words, those in the second column were the most frequently used by British amateurs prior to the war, while the third column gives those used by American amateurs.

A	Able	America	Able
B	Baker	Boston	Boy
C	Charlie	Canada	Cast
D	Dog	Denmark	Dog
E	Easy	England	Easy
F	Fox	France	Fox
G	George	Germany	George
H	How	Holland	Have
I	Item	Italy	Item
J	Jig	Japan	Jig
K	King	Kentucky	King
L	Love	London	Love
M	Mike	Mexico	Mike
N	Nan	Norway	Nan
O	Oboe	Ontario	Oboe
P	Peter	Portugal	Pup
Q	Queen	Quebec	Quack
R	Roger	Radio	Rot
S	Sugar	Santiago	Sale
T	Tare	Turkey	Tare
U	Uncle	University	Unit
V	Victor	Victoria	Vice
W	William	Washington	Watch
X	X-ray	X-ray	X-ray
Y	Yoke	Yokoha ma	Yoke
Z	Zebra	Zanzibar	Zed

WIDE-RANGE R-C OSCILLATOR

From 16 to 18,000 c/s with Nearly Constant Amplitude

By T. A. LEDWARD, A.M.I.E.E.

AN audio-frequency oscillator based on the multivibrator circuit, with modifications to give sine wave output, was described by the writer some years ago* and different forms of RC oscillator have been developed by others. A careful consideration of the principle of operation of the writer's original circuit has enabled him greatly to improve the practical form of this oscillator while retaining, in essential details, the simplicity of the basic circuit.

The oscillator in its new form gives a continuous frequency range in three stages, covering 16 c/s to 18,000 c/s with nearly constant amplitude.

The basic circuit of this type of oscillator is shown in Fig. 1. It will be seen that this is a 2-valve resistance-coupled amplifier circuit in which the second valve is coupled back to the first as in a multivibrator, but the amount of feedback is controlled by means of a potentiometer R_2 and there is a resistance R_1 in series with the grid of V_1. This resistance R_1, while it forms no part of the ordinary multivibrator circuit, is an essential element in the present AF oscillator, as will be seen from the explanation which follows.

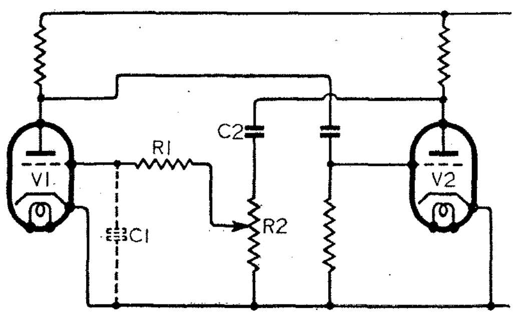


Fig. 1. Basic circuit of the oscillator.

Fig. 2 shows the feedback section of the circuit of Fig. 1. The oscillation frequency is determined by the values of the two condensers and two resistances shown in Fig. 2. R_1 is the resistance in series with the grid of V_1, while C_1 is the total capacitance across the grid and cathode, including the effective internal capacitance due to the Miller effect. C_2 and R_2 form the output circuit of V_2.

Fig. 3 (a) is the vector diagram of voltages for the input circuit of V_1, E_o being the applied voltage derived from the output circuit of V_2. E_{R1} is the voltage drop in the grid series resistance R_1, and E_{C1} is the voltage across the grid capacitance C_1, or, in other words, the true grid voltage of V_1.

The forward coupling from V_1 to V_2 is so designed that the phase angle between the anode voltage of V_1 and the grid voltage of V_2 will be negligibly small at all frequencies within the range of oscillation required. Then the anode voltage of V_2 will be in phase with the grid voltage of V_1. This is shown by the vector E_{A2} of Fig. 3 (b) in phase with E_{C1} of Fig. 3 (a).

This anode voltage E_{A2} is applied across C_2 and R_2 (Figs. 1 and 2). The vectors E_{C2} and E_{R2}, Fig. 3 (b), represent the respective voltages across these components. The relative amplitudes of these voltages, as compared with those of Fig. 3 (a) will of course, depend upon the amplification, and the position of the potentiometer tap that will just maintain oscillation will be such that the voltage at this tap is just equal to the grid input of V_1 required to produce it. In other words, the ratio of the tap volts to the anode volts will be equal to the amplification ratio of the two-valve combination. The potentiometer resistance can, therefore, be quite a small part of the total resistance R_2, a separate fixed resistance being added to make up whatever total value may be required.

It is clear that when oscillation occurs E_{R2} and E_o will be in phase, as E_o is derived from a tapping on R_2.

$\therefore \theta_1 = \theta_2$

$\therefore E_{R1}/E_{C1} = E_{C2}/E_{R2}$

$\therefore R_1/X_1 = X_2/R_2$

where X_1 and X_2 are the reactance values of C_1 and C_2.

$$\therefore X_1 X_2 = R_1 R_2 \quad .. \quad (1)$$

$$\therefore \omega^2 C_1 C_2 R_1 R_2 = 1 \quad .. \quad (2)$$

where $\omega = 2\pi f$

$$\therefore f = 1/2\pi\sqrt{C_1 C_2 R_1 R_2} \quad .. \quad .. \quad (3)$$

where f is the oscillation frequency.

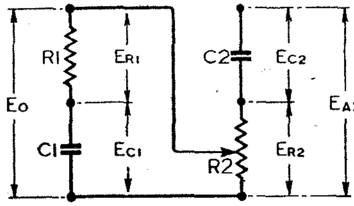


Fig. 2. Equivalent circuit of the feedback section of Fig. 1.

In the original design the capacitance C_1 was the effective grid capacitance of V_1 only, but a study of the principle of operation shows that considerable practical advantages are obtained by making $C_1 = C_2$ and $R_1 = R_2$. Equation (3) then reduces to

$$f = 1/2\pi CR \quad .. \quad (4)$$

where $C = C_1 = C_2$ and $R = R_1 = R_2$.

Further, as $C_1 = C_2$, then $X_1 = X_2$, so that equation (1) becomes $X^2 = R^2$

$\therefore X = R.$

This result means that provided the oscillation frequency is varied by varying both C_1 and C_2 together and keeping them equal, the frequency will always be such that $X = R$. Now let Z = the impedance of either of the circuits C_1, R_1 or C_2, R_2 (which, of course, are equal) then

$$Z = \sqrt{R^2 + X^2}$$

but $X = R$

$$\therefore \quad Z = \sqrt{2}.R = 1.414R.$$

In other words, unless R is changed, the impedance remains constant.

The practical significance of this result is that if $R_1 = R_2$ and $C_1 = C_2$ and the oscillation frequency is varied by varying both C_1 and C_2 together, while R_1

*Wireless World, May 14th, 1937.

Wide-range R-C Oscillator—

and R2 remain constant, the oscillation amplitude will remain constant. This statement ,of course, assumes a constant amplification ratio at all frequencies.

A further advantage of ganging C1 and C2 is that a wide range is covered in a single sweep.

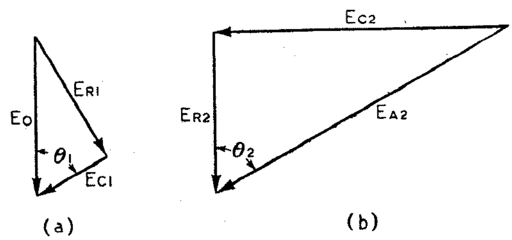


Fig. 3. Vector diagrams illustrating operation of the oscillator.

The complete circuit of a practical audio-frequency oscillator, constructed on the principles outlined above, is shown in Fig. 4.

While the foregoing equations for frequency give a useful approximation to the actual conditions in the practical oscillator, they would need some rather complicated modification if the effect of all refinements included in the practical apparatus were to be taken into account. For instance, some means of applying grid bias to the valves must be included and the best method in this case is to use cathode resistors without the usual large by-pass condensers. The absence of these condensers assists the attainment of good wave form and lowers the minimum frequency obtainable with a given value of R. In order to extend the range at the upper end of the scale, however, a small by-pass condenser is connected across the cathode resistor of V1. This condenser has practically no effect at the bottom end of the scale, but the effect is very marked at the top end, so that the combined effect of cathode resistor and small by-pass condenser is to appreciably widen the whole frequency range. For the attainment of good wave form on range 3, it was found undesirable to make R1 less than 70,000 ohms. A value of R2 equal to 40,000 ohms, in conjunction with other details shown, then gave the required range.

The variable condensers C1 and C2 are each of 0.0015μF maximum capacitance. Each is obtained by paralleling the three sections of a 0.0005μF 3-gang condenser, and the two 0.0015μF condensers thus formed are mechanically coupled in tandem, but insulated electrically from one another.

The two three-way switches A and B, which change the resistance values, are operated together to give the following three frequency ranges :—

(1) 16 to 300 c/s
(2) 250 to 3,500 c/s
(3) 1,200 to 18,000 c/s

The Yaxley type of switch is very convenient and satisfactory for this purpose.

The frequency is continuously adjustable over each of these ranges by the condenser control. The potentiometers P1, P2 and P3 control the amplitude of oscillation and each one is normally pre-set by trial to give the same amplitude for each range. It is then possible to cover the whole range of frequency without very much change of amplitude. P1, the low-range amplitude control, is not connected as a potentiometer, but as a series resistance. This is in order that the spindle may be earthed to avoid hand-capacity effects, which might otherwise be noticeable owing to the high resistance between spindle and earth. Slight changes of frequency occur if the oscillation amplitude controls are altered,

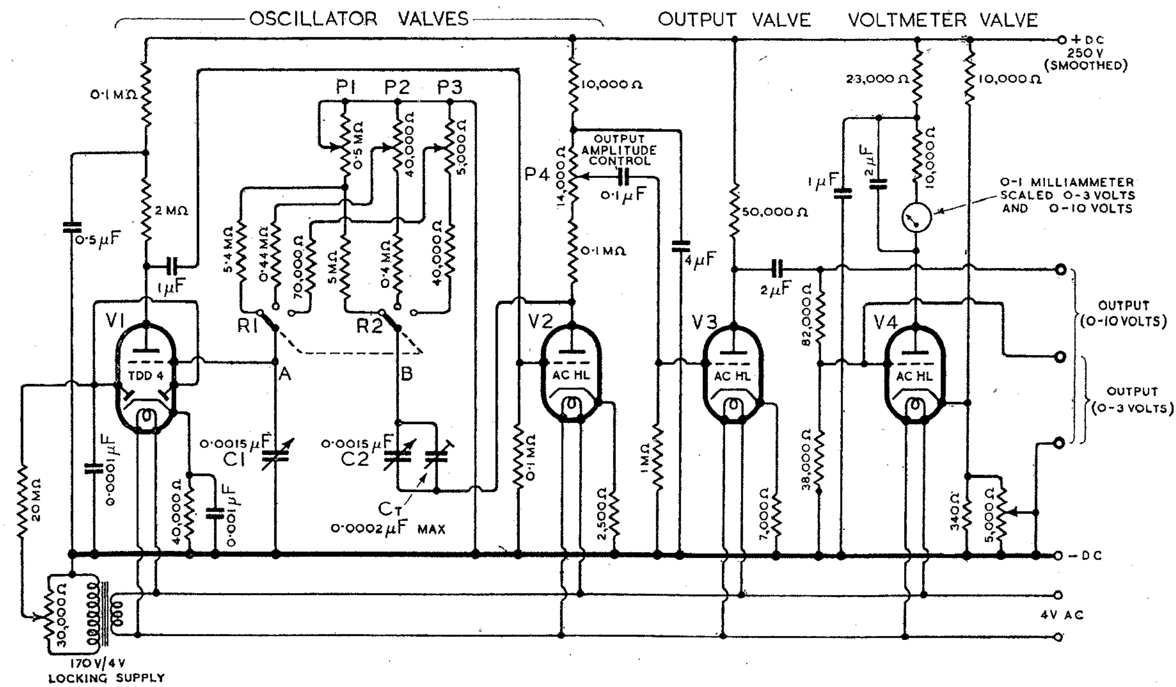


Fig. 4. Complete circuit of the oscillator described.

but as these are normally maintained at a fixed setting, this is of no importance. A separate control for output amplitude is provided which does not affect frequency.

As previously stated, once the controls have been set the oscillation amplitude changes very little over the whole frequency range. The amount of variation that takes place is shown in Fig. 5. In order to maintain such constant amplitude it is necessary, as already explained, to maintain the equality of C1 and C2. In the case of C1 the effective grid capacitance of V1 is added to external stray capacitance in parallel with C1 and it becomes necessary, therefore, to provide an additional trimmer condenser across C2. The trimmer is marked CT in Fig. 4 and should be adjusted on trial until the amplitude is found to be constant at different frequencies. In the writer's instrument the necessary trimmer capacitance was found to be approximately $0.000115\mu F$. Another condition for constant amplitude is that the oscillation should not be too weak. The potentiometers give a smooth control of amplitude and it is found that the best setting is that which gives the maximum amplitude that can be attained without distortion being discernible on a cathode ray screen.

It will be noticed that change of frequency range is effected by changing the values of resistances R1 and R2 by means of switches A and B. A change of resistance would change the oscillation amplitude if the potentiometer setting were unchanged; that is why three separate potentiometers are required, the appropriate one for each range being selected by the switching operation.

It has been stated that the coupling between the anode of V1 and the grid of V2 should be so designed as to give a very small phase angle at the lowest frequency. Such a condition minimises the effect of this coupling on the oscillation frequency or change of amplitude. But it is desirable that this coupling should impose a fairly high damping effect on the anode of V1. A fairly low resistance and large capacitance are therefore indicated. The damping introduced by this coupling and the high value of anode resistor of V1 gives a smooth control of oscillation at low amplitudes. The high value of cathode resistor for V1 is suited to the anode resistor. The grid swing of V1 is very small, but that of V2 is much greater and more normal values of anode and cathode resistors are needed for V2. Negative feedback is, of course, present in both valve circuits, owing to the absence of large by-pass condensers.

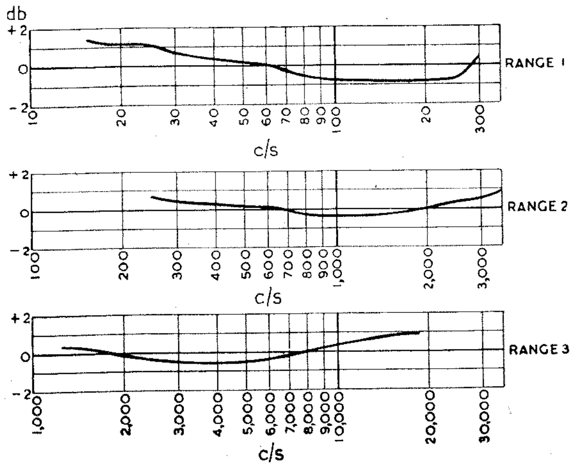


Fig. 5. Amplitude characteristics for the three ranges (odb. is equivalent to 8 volts RMS across 120,000 ohms.)

An output valve V3 is coupled to V2 in such a way that negligible load is imposed on the oscillator circuit. The diagram will make this clear without detailed explanation, but it may be pointed out that control of output amplitude is by means of the potentiometer P4, which controls the input to V3. This arrangement allows the output circuit impedance to remain constant at all amplitudes. It also minimises any distortion in V3, because the lower the amplitude, the lower the input to V3.

A voltmeter valve V4 indicates output volts on the instrument G, which is a 0–1 milliammeter suitably calibrated. The valve is operated as an anode-bend rectifier, and, at normal oscillator amplitude it has no effect on the output wave form.

Initial tests are made with the aid of an oscillograph to determine the maximum output voltage that can be obtained without distortion in the oscillator itself.

No reference has so far been made to the fact that V1 is a double-diode-triode. The diode section is a refinement which assists in providing means for locking any multiple of 50 c/s to the mains frequency (assuming 50 c/s to be the mains frequency). This means that if the oscillation frequency is adjusted to be very nearly equal to any harmonic of 50 c/s, the locking control will pull it into step and hold it at the harmonic frequency. This is accomplished by connecting one or both diodes to the mains supply through a high resistance. It is convenient to provide a variable voltage for this purpose in the manner shown, as the voltage required increases with increase of frequency. The locking is effective up to about 2,000 c/s, but above this a higher locking frequency than 50 would be desirable.

Briefly, the locking action may be explained as follows: Once per cycle of 50 c/s mains voltage a rectified pulse flows through the cathode bias resistor and momentarily increases the negative bias. This action is similar to increasing the value of the bias resistance and tends momentarily to lower the oscillation frequency, hence the effect of "pulling into step." If the pulse were strong enough the oscillation would cease once every cycle of the locking frequency.

Effective screening should be provided for the whole of the apparatus, as the pick-up from AC fields may otherwise be troublesome, and, of course, suitable screening will ensure that the output of the oscillator will be confined to the output terminals.

Institute of Physics.—At the annual general meeting of the Institute of Physics, held recently, the following were elected to take office on October 1st, 1943: President, Sir Frank Smith; vice-presidents, E. R. Davies, Dr. W. Makower and T. Smith; hon. treasurer, Maj. C. E. S. Phillips; hon. secretary, Prof. J. A. Crowther; ordinary members of the Board, Prof. J. D. Cockcroft, D. C. Gall, Dr. H. Lowery, D. A. Oliver, A. J. Philpot and R. S. Whipple. A record increase in membership of the Institute is reported.

CONTRAST EXPANSION UNIT

Design Giving Unequal "Pick-up" and "Decline" Delays

By
D. T. N. WILLIAMSON

It is well known that in broadcasting and recording sound it is necessary to reduce the contrast between the loudest and softest passages. The maximum permissible signal level is rigidly determined by the power-handling capacity of the equipment, and if the full range of contrast is handled the minimum will approach closely the residual noise level, which is obviously undesirable. Thus, if the difference in level between the maximum permissible signal and the residual noise is, say 70 db., and it is desired to maintain a difference between the inherent noise and the minimum signal of 25 db., then it is clear that an original having a contrast range of 60 db. must be compressed to a maximum of 45 db. This is at present usually achieved by manual control at the source, but automatic means will no doubt gradually find favour.

To reproduce such a signal realistically it is desirable that the reproducer should restore the original range. To achieve this it is necessary to arrange that the gain of the reproducing amplifier varies with the variations in *intensity* of the signal. A steady signal requiring a constant gain consists, however, of cyclic variations at audio-frequency, and if the gain were to alter instantaneously it would follow these cyclic variations and alter the waveform of Fig. 1 (a) to that

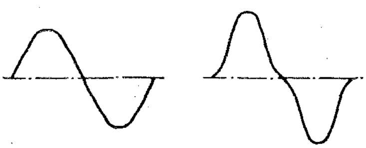


Fig. 1. Waveform distortion produced by instantaneous gain alteration.

of Fig. 1 (b), producing objectionable distortion. It follows, therefore, that it is necessary to introduce some form of time delay to prevent the gain of the amplifier fluctuating at a frequency comparable with the lowest to be reproduced.

By the introduction of this time delay, the rate of change of gain of the amplifier is reduced. If the rate of rise is reduced, a signal of the type shown at Fig. 2 (a)—that is, a transient—is altered to that at Fig. 2 (b), resulting in poor

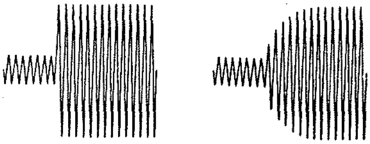


Fig. 2. Effect on a rising transient of time delay in the application of volume expansion.

transient response. On the other hand, if the rate of fall of gain is reduced, the signal of Fig. 2 (a) is unaffected, as it ceases instantaneously; the way in which the gain varies after this is obviously of no importance. The signal of Fig. 3 (a), however, will be distorted to that at Fig. 3 (b).

In general, in acoustics the maximum rate of decay of a signal is considerably less than the maximum rate of rise, e.g., a note of a pianoforte is as in Fig. 4. Also, any reverberation which may be present still further tends to reduce the rate of decay. It is thus apparent that the gain of the amplifier should increase very rapidly, and fall at a relatively low rate determined by the lowest frequency required to be reproduced. This rapid increase will cause some waveform distortion of transients, but this will occur over so short a period as to be inappreciable.

In the usual form of contrast expansion equipment the rates of rise and fall of gain are approximately equal, and a compromise has to be adopted between high rate of change to obtain satisfactory transient response and low rate of change to avoid waveform distortion. The performance of this type of equipment is mediocre, and has given contrast expansion a totally undeserved reputation for transient and amplitude distortion.

The use of manual control of compression leads to anomalies when automatic expansion is in operation. In particular, when the intensity of a loud passage is reduced, the level is not immediately restored at the end of the passage, and so reverberations are kept at the same relative level as the parent sound. Thus, when contrast expansion is introduced, the contrast between the passage and its reverberation is increased, which results in an undesirable attenuation of the echo. This can be avoided by decreasing the rate of fall of gain, holding the gain near its maximum for the duration of the echo. A time of decay of gain of about one second proves very satisfactory in all respects, and gives the added advantage that "flutter" does not occur due to large fluctuations of gain when reproducing music such as the final bars of the Beethoven 5th Symphony, i.e., loud chords separated by short time intervals.

Contrast expansion is most conveniently achieved by means of a variable-gain amplifier, the control voltage being derived from the signal. As is well known, expansion must be carried out at a very low signal level, as attempts to control the gain of a valve handling a large signal will result in distortion. A separate amplifier must, therefore, be provided to obtain a suitably large

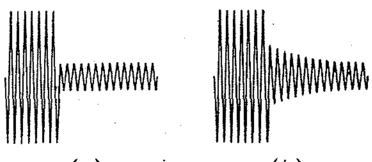


Fig. 3. Distortion produced by time delay in a falling transient.

voltage which is then rectified and fed to the controlled stage through a filter network, by means of which the time delay is introduced.

Fig. 5 shows the basic arrangement of the rectifier and delay circuit. A unidirectional voltage proportional to the instantaneous value of the signal is developed across R1 by the amplifier and rectifier. The rectifier should be full-wave to ensure that the whole waveform appears across R1 with the negative half-cycles inverted, giving a unidirectional voltage which pulsates in a similar manner to the original signal as in Fig. 6 (b). This voltage is in opposition to the standing voltage S, giving a resultant voltage between A and B of the form shown in Fig. 6 (c). This procedure is necessary because variable-gain amplifiers require for control purposes a negative voltage which decreases as the amplification is required to increase. The resultant voltage is applied to the circuit consisting of R2, V and C1. Under no-signal conditions the voltage between A and B is S, and C1 will be charged to this

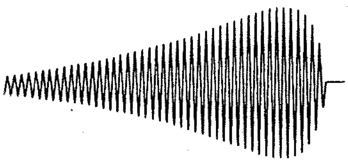
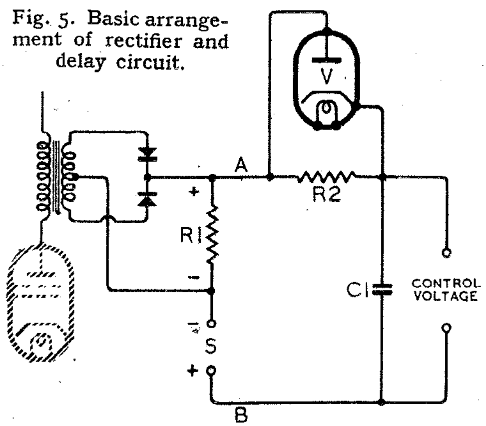


Fig. 4. Waveform of a struck string.

value. On receipt of a signal the resultant voltage AB falls during the first quarter-cycle. C1 will almost simultaneously discharge through the diode V, as the time-constant of C in conjunction with the conduction resistance of V is made small compared with the time of a quarter-cycle. During the next quarter-cycle the voltage across AB will rise, but now the diode is non-conductive and the condenser can charge only through R2, which is of high value to give a time-constant long in comparison with the period of a cycle. C1 thus has insufficient time to acquire any further appreciable charge before the next fall in resultant voltage, and its voltage remains practically steady until a change in signal level occurs. The control voltage for the variable-gain amplifier is taken from C1, and is of the form shown at Fig. 6 (d).

Fig. 5. Basic arrangement of rectifier and delay circuit.



It is apparent that as R1 and the resistance of the supply S are in series with the diode to form the discharge circuit of C1, their values must be kept as low as possible to give a high rate of discharge.

Fig. 7 shows the circuit of a contrast expansion unit which embodies the foregoing principles. Dealing first with the control equipment; V4, the control amplifier, is a single high-slope output tetrode designed to develop a rectified voltage of some 30 V peak in the load resistance R14. It will be adequately loaded by the output of a crystal pickup, but if the output of the preceding equipment is low, an additional stage of amplification must be provided. The standing voltage is obtained by the drop across R17.

R15 and R16, in conjunction with C8, determine the time of fall of gain, and as previously stated, this should be about one second. Insulation difficulties limit the resistance in parallel with the diode to about 4MΩ, and with this value, C8 should be 0.25 μF, giving a time-constant of one second. Some degree of control over the rate of fall of gain is desirable, and for this reason R15 is made variable. R16 sets a lower limit for this delay, to ensure that distortion does not occur.

It is the writer's experience that a time constant of about one millisecond is satisfactory for the discharge circuit which determines the rise of gain; this necessitates that the total resistance of the discharge circuit should not be greater than 4,000Ω. The characteristic of a diode is, of course, non-linear and graphical methods are required to determine exactly the discharge time of the condenser, but a sufficiently close approximation may be obtained by

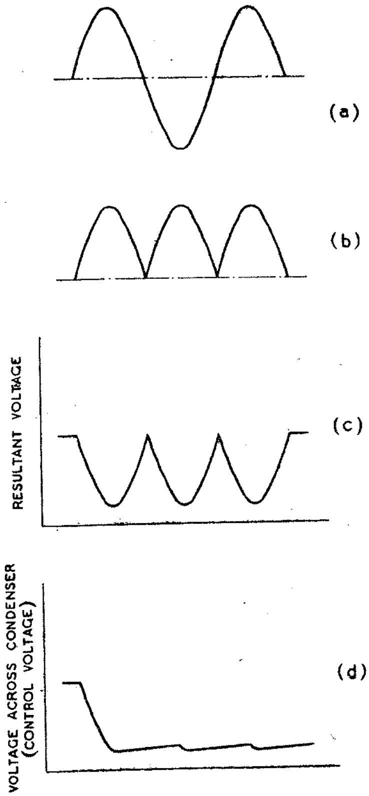


Fig. 6. How the controlling voltage is derived from the signal.

assuming a mean value of resistance over the working range. The diode used is a power-rectifier type, and its resistance over the range in use should be considerably less than 4,000Ω.

The use of an extremely high rate of gain causes difficulties in the amplifier. The rise in anode current which accompanies an increasing gain gives a violent transient. In the case of a single controlled valve this appears superimposed on the output signal, and causes an objectionable noise. The use of a push-pull controlled stage is necessary to eliminate this effect, the transients, which are in the same phase in each valve, cancelling each other, provided balance is correct. The push-pull connection is also advantageous in reducing distortion in this stage, where it is most likely to be present. It is advisable to precede this stage with a phase-splitter, as it is difficult otherwise to provide means for varying the

Contrast Expansion Unit—

signal inputs of both signal and control amplifiers without unbalancing the push-pull arrangement.

It is impracticable to use resistance coupling from the output of the push-pull stage to the input of the main amplifier (unless this is of a type requiring a split phase input isolated from earth), and a transformer must be used. This should introduce negligible distortion, however, as it has no resultant DC magnetisation and will only be called upon to handle signals of the order of one volt. It may be of the nickel-core type.

The method of controlling the amplification of the valves gives some scope for experiment. Variation of the control grid potential is not to be recommended, as it is difficult to arrange matters so that the grid bias is not decreased below the limit for distortionless operation by an unexpectedly large signal. An auxiliary control electrode is therefore desirable and the suppressor grid of a pentode proves satisfactory for this purpose, although other multi-electrode valves may, of course, be utilised. R9 and R10 are included to prevent the suppressor grids being driven positive. The bias for the signal grids is obtained from R17 by the potential divider R18 and R19.

The following procedure is essential for correct operation and should be carefully observed. With the sliders of R12 and R17 at the chassis ends, R1 is adjusted in conjunction with the volume control of the main amplifier so that the latter will just be fully loaded with the loudest expected signal. R17 is then adjusted to give the desired increase in contrast. For convenience, it may be calibrated in db. R12 is advanced until the loudest signal just causes the suppressor grids to be at cathode potential. Any further alteration in volume level should be made by means of R1, rather than with the volume control of the main amplifier, as the former reduces the signal to be handled by the controlled stage.

Equipment on the lines indicated has been used by the writer for a considerable period, and has given very satisfactory results. The distortion of the first cycle or so of transients which theoretically occurs is completely inaudible, due perhaps to the inability of the ear to perceive changes of very short duration.

Quality of recorded music reproduced by this equipment is greatly enhanced and a considerable improvement results from the apparent reduction in surface-noise which takes place due to the expansion process.

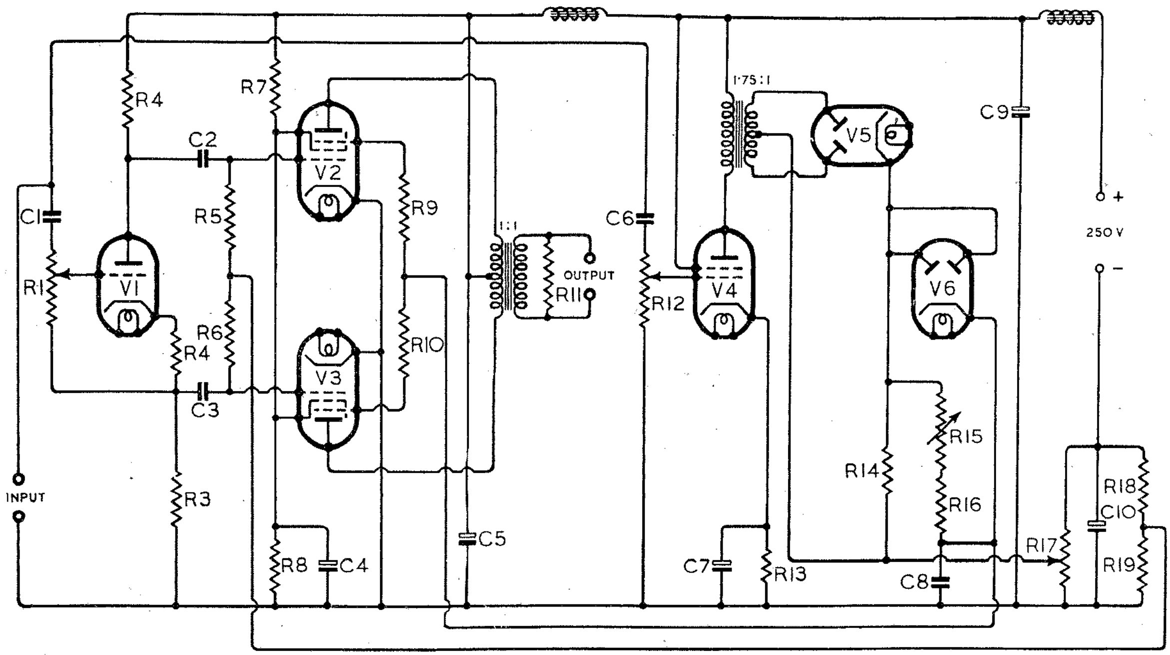


Fig. 7. Contrast expansion unit embodying the principles described in the text. Component values given below.

COMPONENT VALUES

Resistances

R1	1 MΩ	R11	0.1 MΩ
R2	1,000Ω	R12	1 MΩ
R3	25,000Ω	R13	100Ω
R4	25,000Ω	R14	500Ω
R5	0.25 MΩ	R15	4 MΩ
R6	0.25 MΩ	R16	0.5 MΩ
R7	2,500Ω	R17	250Ω
R8	10,000Ω	R18	20,000Ω
R9	0.1 MΩ	R19	3,500Ω
R10	0.1 MΩ		

Condensers

C1	0.01 μF	C6	0.02 μF
C2	0.1 μF	C7	50 μF
C3	0.1 μF	C8	0.25 μF
C4	4 μF	C9	8 μF
C5	8 μF	C10	50 μF

Valves

V1 Osram MH4	V4 Osram KT41
V2, V3 Mazda AC/SP1	V5, V6 Mullard AZ3

THE WIRELESS INDUSTRY

A NEW illustrated leaflet describing four Rothermel-Brush crystal pick-ups, their accessories and method of mounting, has been issued by R. A. Rothermel, Ltd., Canterbury Road, London, N.W.6.

Instrument wires covered with a new plastic enamel having improved mechanical and electrical properties are described in List NSW2 issued by British Insulated Cables, Ltd., Prescot, Lancs. The new wires will be known under the name of "Bicolon."

DESIGN OF SIMPLE OHMMETERS

2.—Formulae and Practical Hints for Designing a Low Ohmmeter

By F. LIVINGSTON HOGG

(Concluded from page 227 of the August, 1943, issue)

WE want the Low Ohmmeter to overlap with the High Ohmmeter described in the last issue. We also want to be able to measure low resistances such as of earth bonding points, soldered joints, etc. This means that 0.1 ohm must be a good sizable reading, and that 0.01 ohm should be seen though not measured accurately. These requirements can be met by three ranges with mid-scale values of 0.5, 5 and 50 ohms.

When the external resistance to be measured is very low, the meter reading will be in error by an amount equal to the resistance of the leads to the prods from the meter circuit. This means that it is necessary to deduct the lead resistance from the scale reading each time a low value is taken. As the lead resistance may easily be 0.05 ohm or so, and a bad joint may be less than 0.1 ohm, this is very inconvenient. There is, however, a simple dodge which gets over this difficulty. Referring to Fig. 5, the circuit supplying power, i.e. E and R_2 is connected across R, and the measuring circuit R_3 and M is connected as closely as possible to the same spot. The common resistance which causes trouble is then very much lower. If heavy brass prods are used, this residual error can be made less than 0.01 ohm.

The final circuit is shown in

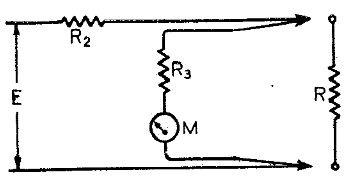


Fig. 5. Errors are reduced if separate leads are used for connecting the meter and battery circuits to the test prods.

Fig. 6, and in simplified form for calculation in Fig. 7. R_{35} is inserted to represent the switch contact and connecting lead resistance. Equating volt drops again we can write down :—

$$E = (I_7 + I_8 + I_9)\,R_{31} + I_9 \,.\, R_{32} \quad .. \quad .. \quad (8)$$

$$I_9 \,.\, R_{32} = (I_7 + I_8)\,R_{33} + I_8 \,.\, R_{34} \quad .. \quad .. \quad (9)$$

$$I_8 \,.\, R_{34} = I_7 \,.\, R_{35} + I_6 \,.\, R_{36} \quad .. \quad .. \quad (10)$$

$$I_6 \,.\, R_{36} = (I_7 - I_6)R \quad .. \quad (11)$$

From these we get :—

$$I_7 = I_6\left(1 + \frac{R_{36}}{R}\right) \quad .. \quad (12)$$

$$I_8 = \frac{I_6}{R_{34}}\left(R_{35}\left(1 + \frac{R_{36}}{R}\right) + R_{36}\right) \quad .. \quad .. \quad (13)$$

$$I_9 = \frac{I_6}{R_{32}}\left[R_{33}\left(1+\frac{R_{36}}{R}\right) + \left(1+\frac{R_{33}}{R_{34}}\right)\left(R_{35}\left(1+\frac{R_{36}}{R}\right)+R_{36}\right)\right] \quad .. \quad (14)$$

Now by equating the resulting value of E obtained from these with the value obtained by substituting for the known case $I_6 = I_{max}$ when R is infinite, we get

$$\left(\frac{I_{max}}{I_6} - 1\right)\left\{1+ \frac{R_{36}\left[\frac{R_{31}}{R_{34}} + \left(1 + \frac{R_{31}}{R_{32}}\right)\left(1 + \frac{R_{33}}{R_{34}}\right)\right]}{R_{31}\left(1 + \frac{R_{35}}{R_{34}}\right)+\left(1 + \frac{R_{31}}{R_{32}}\right)\left[R_{33} + R_{35}\left(1 + \frac{R_{33}}{R_{34}}\right)\right]}\right\} \quad .. \quad .. \quad (15)$$

This fearsome equation is found on inspection to be our old friend (2) in substance, and, neglecting for the moment the effect of variation of R_{31}, we see that if we choose our values correctly we can use a pre-calibrated scale again.

It is a great convenience to have a constant setting adjustment for all ranges. There are two obvious methods of doing this. If current consumption is not important, the scheme shown in Fig. 7 can be used. R_{32} serves to keep the current drain, and therefore the voltage V, constant between ranges. Alternatively three separate controls could be used. We will take the former case, which is a little more awkward to calculate, for our example. It is convenient to supply the necessary voltage from dry cells. If we do this we must remember that during the useful life of the cell the voltage will fall from about 1.5 to 0.8 volts.

We will assume that V the working voltage is 0.7 volt. The meter will be 1 mA full-scale. Its resistance is not likely to be much over 40 ohms, and R_{36} includes this meter resistance. R_{35}, the switch and lead resistance is unknown, but it is unlikely to be over 0.1 ohm. It has an appreciable effect on the ×1 range. We will assume that it is 0.1 ohm, and then we can build it up to this value of test. R_{31}, which is the setting up control, will be taken as 3 ohms for calculation.

We start by calculating R_{36} on ×100, as then R_{34} is infinite. If V is 0.7 volt, and I_{max} is 1 mA, then $R_{33} + R_{35} + R_{36}$ is 700 ohms. This is the elementary case of Fig. 1 (b), with $R_3 = R_{36}$ and $R_2 = R_{33} + R_{35}$. Then if the mid-scale value of R is

Design of Simple Ohmmeters

50 ohms, we can see that, from (2), R_{36} is 54.2 ohms, and R_{33} is 645.7 ohms. R_{32} cannot be calculated accurately at this stage.

For ranges ×1 and ×10 it is convenient to write down :—

$$V = (I_7 + I_8)R_{33} + I_8 \, . \, R_{34} \quad \ldots \quad \ldots \quad (16)$$

Substituting values of I_7 and I_8,

$$V = I_6 \, . \, R_{33}\left(1 + \frac{R_{36}}{R}\right) + I_6\left(1 + \frac{R_{33}}{R_{34}}\right)\left[R_{35}\left(1 + \frac{R_{36}}{R}\right) + R_{36}\right] \ldots (17)$$

And when $I_6 = I_{max}$, and R is infinite

$$V = I_{max}\left[R_{33} + \left(1 + \frac{R_{33}}{R_{34}}\right)\left(R_{35} + R_{36}\right)\right] \quad \ldots \quad \ldots \quad (18)$$

Here only R_{33} and R_{34} are unknown. With small inaccuracy we can take the mid-scale values of R, and solve. However, for best accuracy the figures thus found can be tried and adjusted, together with R_{32}, as necessary until, on substitution in (15), at say mid-scale, the error is negligible. The results are tabulated in Fig. 7.

To evaluate R_{32} it is simplest to calculate $I_7 + I_8$ on range ×1. This gives us the maximum open circuit current, which is also the setting-up condition. Then if we subtract the values of $I_7 + I_8$ on the other two ranges from this value we get the corresponding values of I_9. For this condition the general equations are :—

$$I_7 = I_6 \quad \ldots \quad \ldots \quad \ldots \quad (19)$$

$$I_8 = \frac{I_6}{R_{34}}(R_{35} + R_{36}) \quad \ldots \quad (20)$$

The results for our particular example are given in the table in Fig. 7.

We have now to decide on the maximum value of R_{21}. Our working current is 128.4 mA, and we have to drop a maximum of 0.8 volt, so that a variable resistance covering the range 0 to 7 ohms or so will suffice. It will be noticed that on range ×1, R_{34} is shown as two resistances in parallel, R_{28} and R_{29}. This is for convenience in adjustment, as it is difficult to adjust a low resistance. R_{28} may be made about 0.45 ohm, and R_{29} about 10 ohms. R_{29} is adjusted on test to give the correct value for the combination.

The construction of the instrument is quite straightforward. S_3 and S_4 are ganged break-before-make Yaxley type switches. It was expected that the switch contact resistance would be so variable that it would cause serious trouble, but this has not been found to be so in practice. It is extremely important to wire up with very heavy connecting wire, and make really first-class soldered joints. Owing to the thermo-electric effect, it is necessary for each joint to become cold before any adjustment is tested.

The current can conveniently be taken from two bell type dry cells in parallel. These are switched by means of a double-pole switch, as shown in Fig. 6, to prevent one cell from discharging through the other when off load. The prods may be ¼in. brass rods covered with sleeving, with gramophone needles soldered in for contact points.

The lining up problem is rather more difficult than on the High Ohmmeter. A good method involves the use of two standard resistances on each range. (It will be found that shunts from high-grade meters are useful for this purpose.) One can, with some loss of accuracy, use one resistance on each range, about mid-scale, and use open circuit as the other value. In any case it is very difficult to do without a good Wheatstone Bridge. As the values are somewhat low, special care has to be taken when measuring by indirect methods. A DC voltmeter reading 0.7 volt, and a milliammeter covering 128 mA are also desirable.

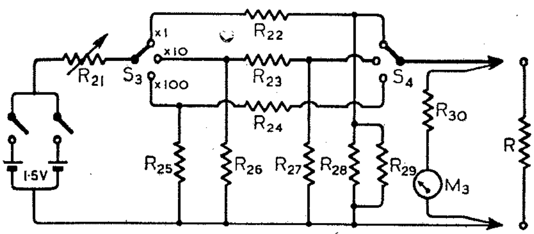
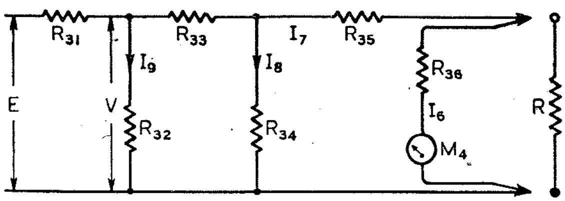


Fig. 6. Circuit diagram of practical Low Ohmmeter. R_{21} = 0 to 7 ohms ; R_{22} = 5.03 ohms ; R_{23} = 63.3 ohms ; R_{24} = 645.7 ohms ; R_{25} = 5.49 ohms ; R_{26} = 5.92 ohms ; R_{27} = 5.9 ohms ; R_{28} = 0.45 ohms ; R_{29} = 10 ohms (approx.) ; R_{30} = 54.2 ohms; M_3 = 0 to 1 milliamp.



RANGE	RESISTANCE OHMS					MILLIAMPERES		OHMS
	R_{31}	R_{33}	R_{34}	R_{35}	R_{36}	I_7+I_8	I_9	R_{32}
×100	3	645·7	∞	0·1	54·2	1	127·4	5·49
×10	3	63·3	5·9	0·1	54·2	10·2	118·2	5·92
×1	3	5·03	0·426	0·1	54·2	128·4	–	∞

Fig. 7. Simplified circuit with values obtained by calculation.

The procedure may be as follows. On range ×100, set V to 0.7 volt, and adjust R_{24} to give full scale deflection on open circuit. Measure a known resistance and adjust R_{30} until the correct reading is obtained. Repeat until both results are obtained without readjustment. Similarly adjust R_{23} and R_{27}, and then R_{22} and R_{29}. So far

R_{35} has been neglected; this affects range ×1 only. Having lined up R_{28} and R_{29}, measure the current taken from the battery on open circuit, with V at 0.7 volt. If the current is lower than 128.4 mA, then the lead from S_4 arm to the prod should be made of slightly higher resistance, and vice versa. Finally, the instrument is set up

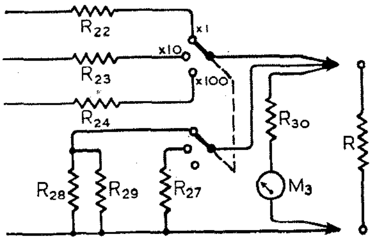


Fig. 8. Circuit modification for eliminating the effect of lead resistance.

on open circuit on range ×1, and then R_{26} and R_{25} are adjusted on ranges ×10 and ×100 to give exactly full-scale deflection without altering R_{21}. If two standard resistances are available for each range, they should be used instead of one resistance and the open circuit condition, the latter being used as an additional check. In practice, if the resistances have been reasonably accurately made and connected up, it will be found necessary to adjust only R_{30}, R_{27} and R_{29}.

The accuracy of this instrument depends even more than the High Ohmmeter on the care and accuracy with which it is made and adjusted. In general, the greatest inaccuracy is on the lowest range, where it is of the least consequence in general radio work. For instance, neglecting the adjustment of R_{35} will cause a mid-scale error of not more than 10 per cent. on 0.5 ohm. The effect of R_{21} is not great, and is worst on the lowest range. The formulae given enable the probable errors to be estimated for any given case, according to circumstances.

Whereas it was found essential to use the protective device on the meter on the high ohm instrument, the need is not nearly so great on the Low Ohmmeter, and it has therefore been omitted.

It should be pointed out that the Low Ohmmeter may have a quite noticeable temperature coefficient on the lowest range, as there is a considerable proportion of copper in some of the low-resistance circuits.

There are numerous deviations from the design given which may sometimes be preferable. For instance, the effect of R_{35} can be to all intents and purposes eliminated by adding a further switch bank, and making the lead to one prod threefold, as shown in Fig. 8.

These instruments are intended for fault-finding and similar purposes, and not to give a high accuracy of measurement. They are, however, much more accurate and useful than many of the universal meters on the market, because they are designed specifically for the purpose.

There is no fundamental reason why the two instruments should not be combined, with a shunt across the meter for the low ohm ranges. It is also possible to extend the High Ohmmeter ranges down lower, but it is recommended that this be done by shunting the meter and not by reducing the voltage further. The micro-ammeter when shunted will probably be very sluggish.

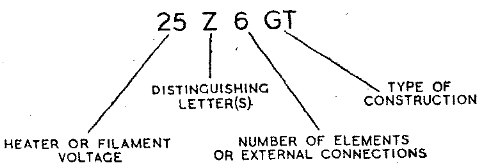
The work of designing these instruments was done by the writer assisted by his colleagues, when he was with Messrs. Standard Telephones and Cables Ltd., New Southgate, London, to whom acknowledgment is therefore due.

American Valve Designations

Interpreting the Type Numbers

IN spite of the fact that a large number of American "Lend-Lease" valves are now available in this country, it seems that many wireless users do not appreciate the meaning of the numbers allotted to the various valve types.

Most current American receiving valves are designated according to a system standardised by the American R.M.A. in 1933. The type number is divisible into four groups having the significance shown in the sketch.



Group 1.—The figure(s) indicates the actual heater voltage, ignoring fractions of a volt, *except* in the case of 2-volt valves, where 1 is used for all voltages below 2.1, and 2 is used for voltages between 2.1 and 2.9 volts. This convention originated from the necessity of distinguishing between the 2.0 and 2.5-volt series.

Group 2.—Type letters were assigned to valves as they were introduced, starting at A for any type except rectifiers, and from Z working backwards for rectifiers. Double letters are now being used for many new valves. If the first letter of a two-letter group is "S" it indicates the single-ended version of an existing type. Thus the 6SJ7 is similar to the 6J7 but its working grid is brought out to a pin in the base instead of to a top cap.

Group 3.—In earlier types this number referred to the number of useful elements; thus a battery triode would be indicated by 3 (filament, grid and anode), but in later types it refers to the number of external contacts—two for heater, one for cathode, etc.

Group 4.—This gives the type of envelope and base; thus M = metal envelope, octal base; G = glass envelope, octal base; GM = metal-coated glass envelope, octal base; GT = short glass envelope, octal base; GL = integral glass envelope and loktal base; ML = integral metal envelope and loktal base; LM = metal envelope and loktal base; LT = glass envelope and loktal base; GB = integral glass envelope and base.

CALCULATING COUPLING COEFFICIENTS

Useful Formulae for Finding the Optimum Spacing of IF Transformer Windings

By S. W. AMOS, B.Sc. (Hons.)

THE sensitivity and selectivity of a superheterodyne receiver depend to a very large extent on the characteristics of its IF transformers and consequently considerable care is necessary in the design of these if a satisfactory performance is desired.

Nearly all IF transformers are of the type illustrated in Fig. 1, i.e., they consist of two wave-wound coils coupled, by means of the mutual inductance existing between them, to give a bandpass effect. The effective bandwidth so obtained depends on the coefficient of coupling between the windings, being given approximately by the expression $\Delta f = f_0 k$

where Δf = bandwidth in kc/s,
f_0 = intermediate frequency in kc/s,
and k = coefficient of coupling between the windings.

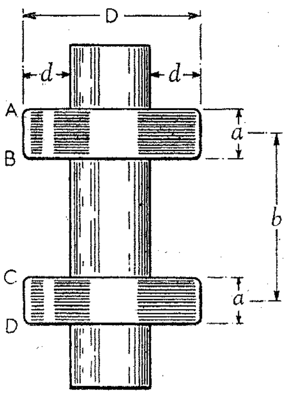


Fig. 1. Type of construction generally used for IF transformers. The calculation of k between the windings is discussed in the text.

Now the performance of such an IF transformer with respect to voltage step-up and selectivity depends also on this coefficient of coupling and is best understood by reference to the curves of Fig. 2, which are based on those given in an article by Reed*. From these it is clear that there is one value of k which gives maximum voltage amplification. This value, known as optimum coupling, is given by $k = \frac{1}{\sqrt{Q_1 Q_2}}$, in which Q_1 and Q_2 are the effective Q values $\left(\frac{\omega L}{R}\right)$ of the two windings. If $Q_1 = Q_2 = 100$, values which are quite common in IF transformers, then the optimum value of k is 0.01.

Optimum coupling, however, gives a poor performance with respect to selectivity, as will be seen from Fig. 2. In fact these two qualities are mutually conflicting, that is to say, increase in gain is generally only possible by sacrificing selectivity and *vice versa*. There is, however, one value of k, actually equal to half optimum coupling, which gives 80 per cent. of the maximum possible voltage gain and the same percentage of the maximum possible selectivity, which represents an extremely good compromise. This article is devoted to the derivation and some applications of a comparatively simple formula for calculating the coefficient of coupling for an air-cored IF transformer (or any other coil assembly which consists of two similar coils mounted on the same former).

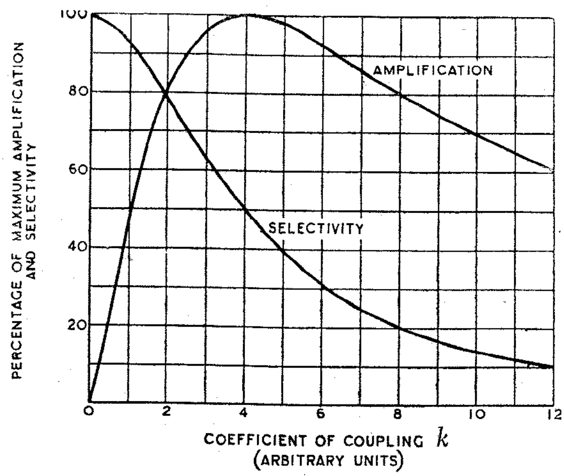


Fig. 2. Curves showing the effect of varying k on the voltage gain and selectivity of an IF transformer.

The value of k between any two inductances L_1 and L_2 is defined by the relationship $k = \frac{M}{\sqrt{L_1 L_2}}$, where M is the mutual inductance between the windings. In the case of an IF transformer $L_1 = L_2$, and we have thus—

$$k = \frac{M}{L_1} \quad \text{(1)}$$

Before we can calculate k, therefore, we must know the value of M. Assume, in Fig. 1, that the space BC has been wound into an inductance with the same type of construction and number of turns per unit length, etc., as for the coils AB and CD. Let the inductances of AB and CD, etc., be represented by L_{AB} and L_{CD}, etc. Then the value of M between the coils AB and CD is given by $M = \frac{1}{2}(L_{AD} + L_{BC} - L_{AC} - L_{BD}) = \frac{1}{2}(L_{AD} + L_{BC} - 2L_{AC})$, since $L_{AC} = L_{BD}$ in an IF transformer.

From expression (1) k is therefore given by—

$$k = \frac{L_{AD} + L_{BC} - 2L_{AC}}{2L_{AB}} \quad \text{(2)}$$

Let the dimensions of each winding be as indicated in Fig. 1 and let the number of turns per unit length on each be n. Now Reyner's formula* for the inductance of a multilayer coil with an air core is

$$L = \frac{0.2N^2D^2}{3.5D + 8l} \times \frac{D - 2.25d}{D} \ \mu\text{H},$$

* "The Design of HF Transformers" by M. Reed. *Wireless Engineer*, p. 349, July 1931.

*See "Radio Communication," by J. H. Reyner. Vol. I. Edition 7. p. 29.

where D = overall diameter of coil in inches, d = depth of winding in inches, l = length of winding in inches, and N = total number of turns on the coil.

Consider the coil AB. In this $N = na$ and consequently its inductance may be written $L_{AB} = \frac{0.2n^2a^2D^2}{3.5D + 8a} \times \frac{D - 2.25d}{D}$, which we will rewrite as $L_{AB} = \frac{0.2n^2a^2D^2h}{3.5D + 8a}$

where $h = \frac{D - 2.25d}{D}$.

Similar results may be obtained for L_{AD} L_{BC} and L_{AC}. Substituting these values in (2) above, and putting $c = b - a$ and $e = b + a$, we have—

$$k = \frac{0.2n^2D^2h\left(\frac{c^2}{3.5D + 8c} + \frac{e^2}{3.5D + 8e} - \frac{2b^2}{3.5D + 8b}\right)}{2 \times \frac{0.2n^2D^2a^2h}{3.5D + 8a}}$$

$$= \frac{3.5^2D^2(3.5D + 8a)}{(3.5D + 8b)(3.5D + 8c)(3.5D + 8e)}$$

$$= \frac{1 + \frac{2.3a}{D}}{\left(1 + \frac{2.3b}{D}\right)\left(1 + \frac{2.3c}{D}\right)\left(1 + \frac{2.3e}{D}\right)} \quad .. \quad (3)$$

As we have already seen, in IF transformers generally the degree of coupling is small (k = 0.01 was quoted earlier) and this is achieved by making b much greater than a. By doing this c, b and e become approximately equal and the expression for k may be written—

$$k = \frac{1 + \frac{2.3a}{D}}{\left(1 + \frac{2.3b}{D}\right)^3} \quad .. \quad .. \quad (4)$$

From this we can see that k is independent of the number of turns on the coils.

As an example of the use of this formula we will calculate the value of k for a typical IF transformer. The component has a = 0.25 in., b = 1.25 in. and D = 0.5 in. Substituting these values in (3)—

$$k = \frac{2.15}{6.75 \times 5.6 \times 7.9} = 0.0072$$

Substituting in (4)—

$$k = \frac{2.15}{(6.75)^3} = \frac{2.15}{307.8} = 0.0070.$$

The difference between these two values of k due to neglecting a in comparison with b in (4) is seen to be small, about 3 per cent.

It is a comparatively simple matter to derive an expression showing the percentage error introduced by the use of the approximate expression (4). Division of (4) by (3) gives—

$$\frac{\left(1 + \frac{2.3c}{D}\right)\left(1 + \frac{2.3e}{D}\right)}{\left(1 + \frac{2.3b}{D}\right)^2} = \frac{1 - \left(\frac{2.3a}{D}\right)^2}{\left(1 + \frac{2.3b}{D}\right)^2}.$$

Hence the percentage error

$$= 100\left(\frac{2.3a}{D + 2.3b}\right)^2.$$

Substituting the values appropriate to the above example' namely, a = 0.25 in., b = 1.25 in., and D = 0.5 in., we get—

Percentage error

$$= 100\left(\frac{2.3 \times 0.25}{0.5 + 2.3 \times 1.25}\right)^2 = 3 \text{ per cent.}$$

Investigation of the expression for the percentage error shows that this will not exceed about 4 per cent. provided b is more than four times a. The value of the ratio b/D does not seem to affect the error very much.

By rearrangement formula (4) enables us to design an IF transformer to have a particular value of k, thus—

$$b = 0.4375\,D\left(\sqrt[3]{\frac{1 + \frac{2.3a}{D}}{k}} - 1\right) \quad .. \quad .. \quad (5)$$

We will assume that a, n and D have been fixed to give the required inductance for each winding and that the Q values of each coil, under actual working conditions, have been measured as 100 . We have already shown that k = 0.01 for optimum amplification in these circumstances We will suppose that the values of a and D are 0.3 in. and 0.6 in. respectively. Substitution of these values and that of k in expression (5) gives b = 1.30 in.

We have already seen that the best performance is given by making k half the value for optimum amplification, i.e. 0.005 in this case. Substituting this amended value of k in (5) gives b = 1.72 in.

It is important to see that the values of Q which are used in calculating k should be those which obtain when the transformer is damped as in the receiver. The secondary winding of an IF transformer which feeds a diode is effectively shunted by a resistance equal to half the value of the diode load resistance. If the load is 100,000 ohms, a likely value in a high-quality superhet, this damping may be serious enough to reduce the Q of the secondary winding to half its normal value. This increases the value of k necessary to secure optimum performance and so decreases the value of b.

EXTENDING EDUCATIONAL OPPORTUNITIES

Brit.I.R.E. Annual Report

THE Annual Report of the British Institution of Radio Engineers lays stress on the fact that the advancement of radio depends upon increased educational facilities; it is a primary post-war objective of the Institution to work for the extension of present opportunities.

Many other aspects of post-war wireless have been considered by the Institution during the year under review, and a meeting has been held with the Post-War Planning Committee of the R.M.A.; liaison with the appropriate committees of other associations is foreshadowed. It is hoped that initial steps taken to bring into being a National Certificate in Radio Engineering will prove fruitful. During the year the Institution was invited to join the Parliamentary and Scientific Committee.

In all, 444 applications for membership of all grades have been received, of which 343 have been accepted (including 40 transfers to higher grades). It has been decided that first-class passes in the City and Guilds Radio Communications Grades 2 and 3 examinations, as well as a pass in Technical Electricity Grade 2, will exempt candidates from the Institution's Graduateship examination. The entire list of examinations carrying exemption has now been revised, as has also the Institution's own syllabus; as a general result, a higher standard of knowledge is called for.

"Oddness" of Standard Voltages

QUESTION No. 14.—Why was the "odd" voltage of 132,000 adopted for the main transmission lines of the Grid System?

[This matter was originally brought up by our contributor "Diallist." Though the question deals with the raw material of wireless rather than with wireless itself, it has raised much interest, and explanations have been offered by many of "Diallist's" correspondents. The question is now passed to our "Brains Trust," and it is suggested that the "oddness" of supply voltages generally has its origin rather earlier in electrical history than is ordinarily believed.—Ed.]

C. R. COSENS, of the Engineering Laboratory, Cambridge, provides an interesting and plausible explanation of why the extremely "odd" factor of 11 came to enter so widely into transmission and supply voltages.

It is doubtful if the explanation given by "Diallist" is tenable; it seems unlikely that the extra 10 per cent. in voltage over the round hundred is to allow for a 10 per cent. drop in the mains. The explanation given to me by an early experimenter seems much more probable. It is as follows:—

Before the adoption of the volt, ampere, etc., as official units—and this was within living memory—EMF or PD was specified as due to so many cells of a given type (Smee, Bunsen, etc.). The chief engineering use of electricity in early days was for line telegraphy (remember that The Institution of *Electrical* Engineers was originally The Institution of *Telegraph* Engineers). The most common telegraph battery was composed of Daniell cells, which had a reasonably constant EMF, and it became customary to specify electrical pressures as equivalent to so many Daniell cells; in fact, the *daniell* very nearly attained the unofficial position now officially occupied by the *volt*. We find in the early literature of electricity such expressions as "an EMF of 50 Daniells."

When, in 1882, it was decided to adopt a practical system of units based on the absolute c.g.s. electromagnetic system of Gauss, with powers of 10 as conversion factors, the factor adopted for EMF was 10^{-8}, so that the new unit—the volt—should be roughly of the same magnitude as the unofficial "Daniell." In terms of the new unit, the EMF of the Daniell cell was found to be about 1.1 volts.

But, before this, dynamos had begun to be used for generating electricity, previously only obtainable from primary batteries. The engineers adopted a round number, 100 or 200, of the then commonly used Daniell cells as their "mains PD." When the volt arrived in 1882 they did not alter the supply pressure, but kept it at the same value of "100 Daniells," and just re-christened it as "110 volts." The era of DC supply, say, 1880 to 1920, saw almost all supply companies giving DC at 110 and 220 volts; there were some three-wire systems of 220-440 volts, and some tramway systems were 550 volts DC.

By about 1890 the Board of Trade had made regulations; amongst others that no conductor in a private house might be more than 250 volts PD above or below earth. Apparently the belief was held that a fatal shock could not occur on less than 250 V, though in this they were mistaken. Hence, when AC came into use, there was a tendency to go as close to this as was possible, and leaving a margin of 10 volts for possible excess over "declared" value, we often got 240 V AC; this was in "single phase" days.

Round about 1900, three-phase AC became more common; with an earthed neutral, the line-to-neutral PD might by law be as much as 250 V, giving a line-to-line voltage of 433. But many supply companies preferred to have a good round number, namely, 400 V, for the line-to-line voltage; then the line-to-neutral," as supplied to a dwelling-house, became $400/\sqrt{3}=231$ volts.

An additional reason against the suggestion that the early engineers allowed 10 per cent. for "mains drop" is found in the clause in early electricity Acts which allowed supply companies to vary the PD at the customer's terminals by not more than ±2 per cent. of the declared value. The penalty for greater variation was £5 a day, half of which was to go to the consumer who complained. Incidentally, it may be doubted if any supply company ever kept mains variations within anything like ±2 per cent., so it is curious that no consumer ever availed himself of this source of income—£2 10s. a day or £912 10s. a year for life! It appears that no action under this clause ever came before the courts. Some 20 years ago the clause was dropped — presumably because the Government, themselves having assumed responsibility for the Grid, thought they might become liable! Variations of 5 per cent. or 6 per cent. are now "allowed," but as there is no penalty for infringement, supplies very often show variations even greater than the extended allowance.

ELECTRICAL INDUSTRIES RED CROSS FUND

Contributions to this Fund are still urgently required, and those firms that have not yet responded to the recent circular letter from the organisers are asked to give sympathetic consideration to the renewed appeal The total of covenanted subscriptions and donations now amounts to about £16,500. Among the latest list of donations from wireless firms and firms with wireless interests are: Gem Mill (Ferranti, Ltd.), £14; Westinghouse Electric International Company, £7; Enfields Radio Services, £5 5s.; Ultra Electric, Ltd., £4 6s.

Information can be obtained from the Joint Secretaries of the Fund, c/o The E.D.A., 2, Savoy Hill, London, W.C.2. Contributions should be sent direct to the Electrical Industries' Red Cross Fund, St. James's Palace, London, S.W.1.

WASTE PAPER

Although the response to appeals for waste paper, books, etc., has been good, there is still a wide gap between the amount of recovered salvage and the country's needs, which are thousands of tons in excess of the weekly salvage collections.

RESEARCH AND PRODUCTION

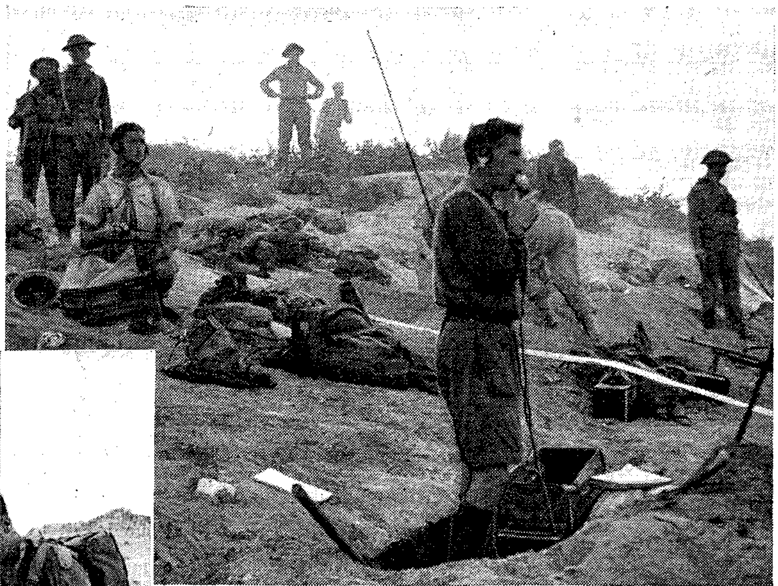
Prospective and Retrospective

"FOR a period after the war—a period possibly of at least some years—a measure of Government control of industry, including the radio industry, is likely to be necessary." Mr. Garro-Jones, Parliamentary Secretary to the Ministry of Production, made this remark when speaking on "Radio Research and Production Before, During and After the War," at a recent meeting of the Radio Industries Club.

During his speech he drew some interesting comparisons between the pre-war and present position of the industry. In pre-war days about 80 per cent. of the 80 specialist firms comprising the radio industry, which had an annual turnover of about £25,000,000, was devoted to the production of broadcast receivers. The remaining 20 per cent. was devoted principally to the production of broadcasting transmitters and telecommunications apparatus. The ratio of skilled to unskilled labour in firms producing broadcast sets was of the order of 1:30, and in the firms producing communications equipment it was about 1:10.

Four years of war have seen a very great transformation in the industry. Virtually the whole of the present output, which is many times greater than before the war, consists of operational equipments for the Armed Forces. "In fact," said Mr. Garro-Jones, "production of broadcast receivers for civilian use has been curtailed to such a degree that the manufacture of additional receivers for British homes is now becoming an urgent matter." Many types of apparatus which are now produced for the Fighting Services are very different in character from pre-war productions. A higher degree of technical skill in production is therefore necessary in a large number of cases (for example, in many radiolocation equipments the required percentage of skilled/unskilled labour was at one time of the order of 1:4 and is still of the order of 1:8).

Mr. Garro-Jones said the radio laboratories of the defence services, though under-staffed, under-equipped and under-financed, had done solid work, of a development rather than a research kind, on equipment which, like much of the military equipment here and in Germany, was doomed to be obsolete before the great clash came. Radiolocation was, he said, by far the most important national asset ever to emerge from the National Physical Laboratory. It was a natural but not inevitable synthesis of techniques developed within the Radio Research Board's programme. It revivified the laboratories of the defence services. The wisdom of Sir Edward Appleton and of Sir Henry Tizard and his colleagues of the Tizard Committee, supported as they were by the Government and its highest advisers, not only contributed to



SHIP-TO-SHORE communication between landing parties and headquarters vessels is essential in invasion. A Signals Section on the Sicilian beach is shown establishing communication with a Signals station afloat (see our cover illustration). Complete stations mounted in "prams," as shown left, were brought ashore during the landings

Research and Production—
save our country, but to the re-shaping and enlargement of the radio industry.

A "common meeting ground for the service man and the scientist" is now provided by the Operational and Technical Committee of that "still young organ of the War Cabinet," the Radio Board. "Our radio world," said Mr. Garro-Jones, who is chairman of the Production, Planning and Personnel Committee of the Radio Board, "is a technical democracy in which the civilian junior scientific officer hears directly from the Admiral's mouth what he wants, and the Air Marshal hears from the junior civilian's mouth what he ought to want and why."

Referring to the post-war application of new devices such as radiolocation, which, incidentally, is now officially given the American name "radar," the speaker pointed out that in the civil aviation and mercantile marine fields many radio aids to navigation, etc., can only be fully effective if introduced on an international basis and with international agreement not only in regard to wavelengths, etc., to be employed, but also in regard to standardisation of the facilities. Technical progress on ultra-short wavelengths, resulting from war-time research and development, has opened up the possibility of new national broadcasting services of a quality which was unobtainable in the overcrowded pre-war long-wave and medium-wave broadcast bands.

FM AND FOLIAGE

MEASUREMENTS taken in Milwaukee, Wisconsin, have shown that the foliage on trees has an adverse effect on the reception of frequency-modulated transmissions.

The president of FM Broadcasters, Inc., states it has been proved that within the 1 mV/m service area of an FM station there was a fall in signal strength during the summer of an average of 15 per cent. where receivers were installed in houses completely surrounded by trees. Outside the ½ mV/m area the drop in signal strength is said to average as much as 50 per cent. The strength of the signal increased considerably during the autumn and winter.

NEWS IN ENGLISH FROM ABROAD

REGULAR SHORT-WAVE TRANSMISSIONS

Country : Station	Mc/s	Metres	Daily Bulletins (BST)
America			
WKRD	5.985	50.12	0600, 0700, 0800, 0900
WLWO (Cincinnati)	6.080	49.34	0600, 0700
WBOS (Hull)	6.140	48.86	0900, 1000‡
WCBX (Brentwood)	6.170	48.62	0500
WGEA (Schenectady)	6.190	48.47	0515, 1000‡
WKTM	6.370	47.10	0600, 0700, 0800, 0900
WLWO (Cincinnati)	7.575	39.60	0900
WKRD	7.820	38.36	0000, 0100, 0200, 0300, 0400, 0500, 1000‡, 1100, 1200, 2300
WCRC (Brentwood)	9.650	31.09	0600
WNBI (Bound Brook)	9.670	31.02	0000
WKRD	9.897	30.32	2100
WKRX	9.897	30.32	0100
WCRC (Brentwood)	11.830	25.36	1100, 1200, 2045
WGEA (Schenectady)	11.847	25.33	1200, 1300, 1500‡, 1600, 1700
WKRD	12.967	23.14	1300, 1500‡, 1600, 1700, 1800
WLWO (Cincinnati)	15.250	19.67	1400, 1500, 2200
WCBX (Brentwood)	15.270	19.65	2045
WGEO (Schenectady)	15.330	19.57	1100, 1200
WRUW (Boston)	17.750	16.90	1500‡, 1600
WLWO (Cincinnati)	17.800	16.85	1700, 1800, 1900, 2000
Algeria			
Algiers	8.965	33.46	1600, 1700, 1800, 2100, 2200
	12.110	24.77	1700, 1800, 2100
Australia			
VLG3 (Melbourne)	11.710	25.62	0800
VLI2 (Sydney)	11.872	25.27	0800
Brazil			
PRL8 (Rio de Janeiro)	11.715	25.61	2030‡
China			
XGOY (Chungking)	9.635	31.14	1500, 1700, 2130
Egypt			
Cairo	5.785	51.85	1125, 1740
	7.510	39.94	1125, 1740
French Equatorial Africa			
FZI (Brazzaville)	11.970	25.06	2045
India			
VUD3 (Delhi)	7.290	41.15	0800, 1300, 1550
VUD4	9.590	31.28	0800, 1300, 1550
VUD3	15.290	19.62	0800, 1300
Mozambique			
CR7BE (Lourenco Marques)	9.830	30.52	1155, 1712, 1915
Newfoundland			
VONH (St. John's)	5.970	50.25	2315
Spain			
EAQ (Aranjuez)	9.860	30.43	1815
Sweden			
SBU (Motala)	9.535	31.46	2220‡
Switzerland			
HER3 (Schwarzenburg)	6.165	48.66	2150
HER4	9.535	31.46	2150
Syria			
Beirut	8.035	37.34	1820
Turkey			
TAP (Ankara)	9.465	31.70	1800
U.S.S.R.			
Moscow	5.890	50.93	2100, 2200
	6.980	42.98	1800, 2200, 2300
	7.300	41.10	1800, 2000, 2100, 2200
	7.330	40.93	2000, 2100, 2200
	7.560	39.68	2100
	10.445	28.72	1240
	11.830	25.36	1600, 1700
	12.190	24.61	1240
	15.230	19.70	1240, 1515
	15.750	19.05	1240
Vatican City			
HVJ	5.970	50.25	1915

MEDIUM-WAVE TRANSMISSIONS

Country : Station	kc/s	Metres	Daily Bulletins (BST)
Ireland			
Radio Eireann	565	531	1340‡, 1845, 2210

It should be noted that the times are BST—**one hour** ahead of GMT. The timing of some of the bulletins may be changed to compensate for the reversion to BST. ‡ Sundays excepted.

WORLD OF —— WIRELESS

B.B.C. CONSTITUTION

REFERENCE was recently made in the House of Commons to the constitution of the B.B.C. and the lack of effective Parliamentary control over its activities and organisation. In reply, the Minister of Information said the charter of the B.B.C. was approching its end [actually December, 1946] and Members would do a great deal of good in pressing for a "complete examination of the whole set-up of the corporation." He added: "While it had made many mistakes, it was the best broadcasting organisation in the world, and the European section had fulfilled the best hopes."

FREQUENCY ALLOCATIONS

THE use of ultra-high-frequencies for the U.S. airways communications instead of the 200 to 400-kc/s band is foreshadowed in a recent statement issued by the Office of War Information regarding the post-war reorganisation of American airways.

It is pointed out by the Civil Aeronautical Authority that the immediate post-war problem of the airways will be "to rebuild the [communication] system by substituting ultra-high-frequencies for the old standard intermediate frequencies."

The proposed change is bound to have repercussions on existing services in the UHF band and also on the anticipated extension of FM broadcasting.

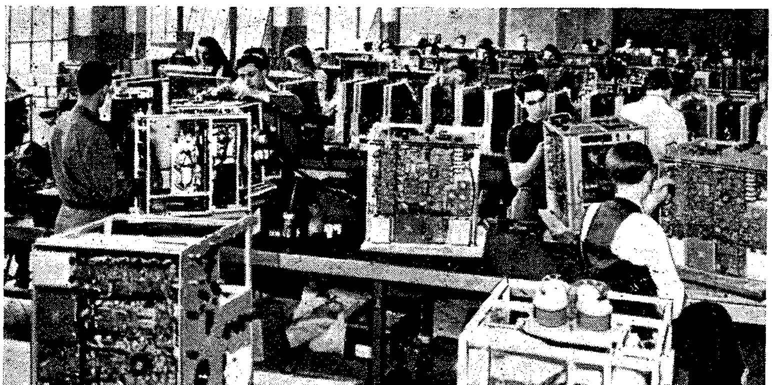
Commenting on the proposal, our American contemporary *Broadcasting* points out that whilst the 200 to 400-kc/s band is well suited for broadcasting there is some inclination towards a greater use of the top end of the frequency spectrum for post-war broadcasting. The situation will also be aggravated by the proposed use of UHF relay stations for FM networks.

It is obvious from this and other recent statements on the post-war allocation of frequencies that it will be necessary to have an international telecommunications conference to settle this vexed question. The last telecommunications conference was held in Cairo in February, 1938.

"FATHER OF RADIOLOCATION"

THE Honorary Degree of Doctor of Laws was recently bestowed upon Sir Edward Appleton, K.C.B., F.R.S., Secretary to the Committee of the Privy Council for Scientific and Industrial Research, by Lord Cecil, Chancellor of Birmingham University.

At the investiture, Prof. Ritchie, the University's Public Orator, welcomed Sir Edward as the one "responsible for the whole of the Government activities in research in physical sciences." He said: "As the result of his dealings with



RADAR equipment for the U.S. Navy in process of production at a General Electric factory in New England. This is the first photograph to be released from the States showing, with any degree of clarity, the construction of radar sets.

World of Wireless—

the upper air, Sir Edward Appleton became the father of radiolocation. It was a relatively simple step to pass from the observation of reflecting layers in the upper atmosphere to the detection of aircraft. . . . The methods of radiolocation differ only in detail from those devised by Sir Edward from the study of a purely scientific problem. In other words, he is among the few, the glorious few, who won the Battle of Britain."

SHORT WAVES FROM NORTH AMERICA

ACCORDING to the latest figures given in the States, there will probably be 36 short-wave broadcasting stations radiating programmes oversea by July, 1944. In June, 1942, there were only 14 transmitters in use.

The power of some of the new transmitters, which are being erected as quickly as manufacturing facilities permit, will be as high as 250 kW.

Originally it was planned to employ 22 transmitters on the East Coast and 14 along the Pacific Coast, but later developments of war may necessitate a change being made.

The 22 new transmitters planned for erection during the next year are being allocated to the seven companies operating the existing stations.

NEWS IN MORSE

FOLLOWING requests from readers for details of the schedule of transmissions of news bulletins in morse, we are giving below the latest information regarding these broadcasts from the G.P.O. stations, which, although intended for oversea listeners, may, under suitable conditions, be heard in this country.

The call signs, which include two new ones—GCP and GBC5—and the wavelengths employed for these transmissions are:—

GIA: 15.27 m.	GIM: 23.13 m.
GAD: 15.40 m.	GCP: 27.86 m.
GBL: 20.47 m.	GIH: 28.17 m.
GID: 22.13 m.	GAY: 33.67 m.
GBC5: 34.56 m.	

The times (GMT) of the broadcasts and the transmitters radiating them are:—

0048: GBC5, GIJ.
0930: GIA, GID, GIH.
1302: GAD, GIA, GID.
1602: GAD, GIA, GID.
1800: GIM, GCP, GAA.
2000: GIM, GBC5.

In addition to the above, the B.B.C. radiates bulletins in morse at 0030, 0100 and 0130 (GMT) in English, German and French respectively. These transmissions are radiated on a number of wavelengths in the 49-, 41- and 31-metre bands.

AMERICA'S BLUE NETWORK

IT is learned that the American chain of broadcasting stations originally operated by the National Broadcasting Company as the Blue Network has been sold by Radio Corporation of America, the parent company, to Edward J. Noble, millionaire candy manufacturer. Temporarily known as the Blue Network Company Inc., it includes 157 medium-wave broadcasting stations. Three of these transmitters, WJZ, New York, WENR, Chicago, and KGO, San Francisco, are owned by the company, the remainder being affiliated on a time basis.

The company proposes having news reporters in Cairo, Algiers, Stockholm, Moscow, and Ankara. George Hicks is the European manager, with offices at 2, Mansfield Street, London, W.1.

AWARDS TO RADIO OFFICERS

"LLOYD'S War Medal for Bravery at Sea," which is struck in silver with a ribbon of blue and silver, is bestowed upon officers and men of the Merchant Navy and Fishing Fleets in cases of exceptional gallantry at sea in time of war. The latest list of awards includes the names of Radio Officer Ernest Sturdy (deceased) and Radio Officer Thomas Simkins. Radio Officer Sturdy remained in his cabin to send out a distress message after his ship was torpedoed. The ship sank quickly and he was drowned. Radio Officer Simkins' ship was hit and set on fire by Japanese bombers in Far Eastern waters. During the attack Radio Officer Simkins showed fearlessness in climbing the ship's mast to renew the aerial, which had been destroyed.

The George Medal has been awarded to Chief Radio Officer Donald Wilfred Dennis who, when his ship was torpedoed and set on fire, volunteered to release the only undamaged boat. Although he was badly burned, he crawled through the flames on his hands and knees and released the falls. Throughout he displayed outstanding courage and fortitude; but for his brave act the boat would not have got away and there would have been few, if any, survivors.

The King has approved the appointment as a Member of the Order of the British Empire (Civil Division) of Chief Radio Officer Bert King, who displayed outstanding courage and devotion to duty, remaining on board his torpedoed ship until it sank.

FM PROGRESS

AMERICANS' confidence in the future of FM broadcasting is shown by the number of applicants for FM transmitting licences.

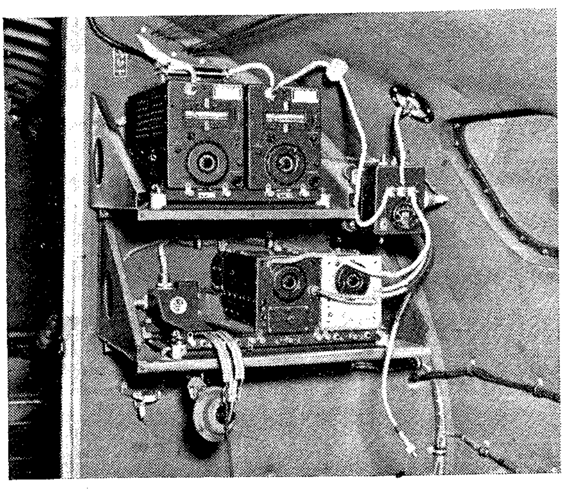
In addition to the 50 or more stations already operating and those for which construction permits have been granted although they are nc yet in operation, there have beel applications for licences for the erection of 40 more.

A number of stations already in use are operated by educational authorities. The transmissions from the station operated by the San Francisco Board of Education are received by 80 schools in the San Francisco area.

FLYING FORTRESS RADIO

THE successful daylight sorties over Germany of Flying Fortresses of the U.S. Eighth Army Air Force operating from this country makes it opportune to give a few details of the planes' radio equipment.

The radio operator, who, because he is a trained gunner and has a 0.5 calibre machine-gun in his cabin, is sometimes referred to as a radio gunner, has to operate a comprehensive array of apparatus. It includes duplicate "command" transmitters and receivers for intercommunication between planes in the formation ar what is known a a liaison set, which is for communication with the base from which the plane is operating.



A CORNER of the operator's quarters in a Flying Fortress showing the duplicated transmitters (top) and receivers (bottom) for intercommunication between planes in the formation. The unit on the right is the aerial switching relay.

There is also the usual blind-landing apparatus, crew intercommunication gear, and radio compass. In addition there is a UHF combined transmitter-receiver.

The operator's job is largely one of listening, but he has to be capable of sending morse at 16 w.p.m.

All aviation communications equipment is maintained by personnel of the U.S. Signal Corps attached to the Eighth Air Force Service Command.

POST-WAR PLANNING

A POST-WAR planning committee, with terms of reference covering radio manufacturing and research, was proposed by the U.S. Radio Manufacturers' Association at its recent annual conference. The necessity for a comprehensive plan embracing all radio services, both transmitting and receiving, was emphasised by J. L. Fly, chairman of the Federal Communications Commission. "After this war," he said, "we must ensure that all phases of radio will be re-established on a firm and spacious foundation. Not the least challenging of our ultra-modern developments is the opening of the limitless ranges of the higher frequencies. We cannot satisfy all the demands for frequencies and yet the problem must be constantly considered."

U.S. VALVE POSITION

A WEAKNESS in the method of distribution has allowed large quantities of valves manufactured for the express purpose of maintaining civilian sets in the States to fall into the hands of set manufacturers with the result that there has been an acute shortage of replacement valves for the public.

In an unsuccessful endeavour to stop the leakage, valves were marked "MR" (maintenance and repair). The latest order makes it legal for "MR" valves to be used for any other purpose than for the maintenance and repair of civilian sets.

According to the U.S. Radio Manufacturers' Association, some 2,000,000 valves were manufactured monthly during the beginning of this year for civilian requirements.

IN BRIEF

"Picture by Wireless."—A radio photo-telegraphic service between London and Montreal was opened a few days before the arrival of the Prime Minister and his party in Canada. Cable and Wireless are operating the terminal on this side of the Atlantic, and the Canadian Marconi Company that on the other side.

Canadian Wireless School Subsidised.—The Minister of Munitions in the Canadian House of Commons obtained approval for a sum of approximately £25,000 for the subsidisation of radio operator students taking a course at a school operating in association with the University of Toronto. Students receive a small salary when taking the course.

Second-hand Sets in Canada.—An order issued by the Wartime Prices and Trade Board in Canada establishes a maximum selling price schedule for used receivers and valves. The dealer must guarantee every used set sold and prices are based on the age and type of set. The price charged for a used valve must not be more than 25 per cent. of the price charged in the same district for the same kind of valve when new.

B.B.C. News on Short Waves.—It should be noted that the times given in this schedule of B.B.C. transmissions of news in English on short wavelengths, which will be operative when this issue of *Wireless World* appears, are BST (one hour ahead of GMT).

0015†	25.53, 25.68, 30.53, 31.32
0206 ...	25.53, 25.68, 30.53, 31.32, 42.46
0345 ...	25.68, 30.53, 30.96, 31.32, 41.96, 42.13, 42.46, 48.43, 49.10
0530 ...	25.68, 30.53, 30.96, 31.32, 42.13, 48.43, 49.10
0605 / 0715	16.92, 19.91, 25.38, 25.47, 25.53, 25.68, 30.53, 31.25, 31.55, 42.13
0830 ...	16.92, 19.91, 25.53, 25.68, 30.53, 31.55, 42.13
0900 ...	24.80, 25.58, 31.12, 31.25, 31.32, 31.61, 31.75, 31.88, 41.01, 41.32, 41.96, 42.46, 48.43, 49.59, 49.98
0958 ...	16.92, 19.44, 19.60, 19.91, 25.53, 25.68, 31.55
1200 / 1400	13.97, 16.64, 16.79, 16.84, 19.44, 19.60, 19.91, 25.53
1600 ...	13.97, 16.64, 16.79, 16.84, 16.92, 19.44, 19.46, 19.60, 24.92, 25.68, 31.55
1700 ...	16.59, 16.64, 16.92, 19.66, 25.53
1745 ...	25- and 49-m bands
1900 ...	16.92, 19.66, 19.82, 25.29, 25.53, 31.75, 42.46
2145 ...	16.92, 19.66, 25.29, 25.53, 30.53, 31.25, 31.41, 31.55, 31.88, 41.49, 41.75, 41.96, 42.46, 48.98, 49.42, 49.92
2245‡	25.53, 25.68, 30.53, 31.32
2300 ...	31.25, 42.46
2345 ...	25.53, 25.68, 30.53, 31.32

† Sundays only. ‡ Sundays excepted.

Institution of Electrical Engineers.—It is proposed by the committee of the South Midland Centre of the Institution to form a Wireless Group. A questionnaire is being circulated to members of the Centre to ascertain their interest in wireless or high-frequency engineering, and whether they would be prepared to support the idea of a Wireless Group and attend meetings. Particulars may be obtained from H. Hooper, Hon. Secretary, 65, New Street, Birmingham.

Radio Relays.—An increase of 12,871 subscribers in the three months to March 31st last is revealed by latest radio relay statistics. At this date there were 447,944 subscribers.

Canada and Radio.—As a result of a survey of radio in the Dominion of Canada, it is estimated that 1,900,000 homes out of 2,700,000 own receivers.

Brit.I.R.E. Officers.—The appointment of the new officers of the British Institution of Radio Engineers, as given in our August issue, does not become effective until the annual general meeting. The meeting has been arranged for 6.15 on Thursday, September 16th, at the Institution of Structural Engineers, 11, Upper Belgrave Street, London, S.W.1.

RANDOM RADIATIONS

By "DIALLIST"

Utility Sets

SO far I have made no comment on the proposed utility broadcast receivers that may be one of the features of life in wartime, but I feel now that I would like a word or two. There is much to be said both for and against the scheme. Its main "pros" are that it offers a way of providing the public with respectable quantities of receivers at moderate prices, and that these simple, more or less standardised sets should make the problems of servicing and of component replacement easier than they are now. The "cons"? Well, the utilities naturally won't be high-class performers as regards either sensitivity or quality of reproduction. Some manufacturers fear that once the public finds that such cheapish sets are good enough for bringing in the news bulletins and some entertainment from the local station, it will never go back to the better set when it is available again. I don't believe a word of that. For more than a dozen years many manufacturers have, in my view, taken an unwise line in educating the public not *up* but *down* to the kind of set that was selling at from £8 to £12 or thereabouts before the war. And a large section of the public showed that it wanted something better, refusing to go as far down the slippery slope as some sections of the industry would have led them. Moreover, a set with poor sensitivity and selectivity, though it may answer during the war, will hardly be good enough afterwards. Any retailer will tell you that the first question he is asked about a set by nine prospective buyers out of ten is: How many foreign stations will it bring in? The fact that the enquirer, having turned from a prospective into a real purchaser, seldom listens to anything but the local station after the first month has passed is neither here nor there; sensitivity and selectivity are the qualities of a wireless set uppermost in the mind of the man-in-the-street, and he's jolly well going to have them when he buys his peacetime receiver.

No Harm Done

All things considered, then, the utility set is no more likely to influence post-war tastes than the utility suit. The man-in-the-street will regard it as just as much of a wartime makeshift. As soon as may be after peace has returned, his two-valve utility set will follow the depocketed jacket and the turn-upless trousers of his utility suit to the jumble sale. What we need now—and the need is growing daily as more and more ancient receivers become beyond repair—is a set that can be provided in large quantities by such semi-skilled labour as is available in the factories. Numbers are the great thing, and in wartime we can't have sufficient quantities of the more elaborate sets that would normally be produced. In the ordinary way I'm all against lowering the price and the performance of sets: I do not much mind whether the manufacturers turn out station-getters or not so long as they don't try to make the public believe that wireless reproduction must have no top and a carpet-beater bass; but in wartime I am quite prepared to accept the utility set as a temporary expedient, believing, as I do, that when happier days return it will pass, leaving behind it as few regrets as will soya-bean sausages, wooden-soled shoes, five-inch socks, and all the other minor horrors of war.

□ □ □

Early Complex Valves

A CORRESPONDENT reminds me that one of the reasons for the production of two-in-one and three-in-one valves in the mid-nineteen-twenties was the queer royalty system for wireless sets which then prevailed. He is quite right: I had clean forgotten what was perhaps the main reason why, in its early days, popular wireless reception developed along such different lines here and in the U.S.A. Any British set that you bought had to add to its price a royalty of so much per valve holder. Motor cars were handicapped in much the same way by the horse-power tax. Neither of these things obtained in America. Over there cars rated at 20-30 horse-power were the popular models. Here manufacturers strove to get the last ounce out of small engines. Similarly, quite early American domestic receivers contained numerous valves, whilst two or three, all working fit to bust, were for a long time the rule here. Then the Loewe Company had the brilliant idea of fitting two or more electrode assemblies, with coupling resistances and condensers, all into one gigantic bulb which could be inserted into a single holder. Later we continue to suffer badly from the same few valve-holder complex, even when this form of royalty had gone: we designed valves with slopes like the side of a house and continued to work them all out: seldom, in fact, can so much have been done for so many by so few. Later still we went all complex-valve minded, largely because the ordinary man was afraid of the expensive replacements that might be needed if he bought a set containing more than four valves, excluding the rectifier. I hope sincerely that after the war we shall enter an era of bigger and better sets, containing simpler valves and more of them.

□ □ □

Grid System Voltages

EVERY month brings me a goodish number of letters from readers, all of them interesting and most of them helpful. But never before has there been such a mass of correspondence as was evoked by my innocent query, "Why was 132 kV adopted as standard for the main transmission lines of the Grid System?" Since I wrote on this subject last month, more letters have come in, and more information can be pieced together. First of all, the most economical way of sending power over long distances is to use the three-phase system. For industrial purposes a three-phase supply at 400 volts is required; for household heating, lighting and so on one phase of a star system is used, and the voltage here is, of course $400/\sqrt{3}$, or 230 volts. In order that 400 volts may be ensured in the final distribution lines it is necessary to allow an ample margin in main and subsidiary transmission lines. Ten per cent. had been found by experience to meet requirements here. Hence, though 10,000 was the nominal voltage of short-distance transmission lines, 30,000 or 60,000 that of secondaries, and 120,000 that of main grid lines, the working voltages were fixed at 11,000, 33,000 or 66,000 and 132,000 respectively.

How It Works Out

For certain main alternators a voltage of 6,600 had been found to be a satisfactory figure. A twenty-fold step-up by means of transformers gave the main transmission line voltage of 132,000, or 120,000 plus ten per cent. Before the Central Electricity Board came into being there were already lines with voltages of 66 kV, 33 kV and 11 kV in existence, and integral transformation ratios enabled these to be brought into the system. Thus the apparently odd figure of 132 kV, with its factors of $4 \times 3 \times 11$ is seen to have been the result of careful calculation. It is curious that, though I have more than once put the question to electrical engineers and have heard it discussed between them, I never had a completely satisfactory answer until readers of *Wireless World* took a hand.

Early History

Having just had a few days of blissful and blessed leave at home I have been able to get at some of my reference books and to dig out some rather interesting facts. Apparently the highest transmission line voltage used in this country prior to 1922 was some 40 kV. In 1926 this had risen to 66 kV, used by the County of Durham Electric Supply Company. Much higher voltages had been used to cover the greater distances that had to be spanned in other parts of the world. Until the suspension type of insulator was introduced 66 kV was the upper limit; but by 1911 100-110 kV lines were in operation in Canada, the United States and Germany. In the next five years systems with voltages up to 165 kV were developed in many countries. By 1926 the U.S.A. had four 220-kV lines built or building and a fifth planned. The Boulder Dam line is designed for 276 kV. A line voltage of 132 kV was in use in Sweden and in Australia before our system was established. Two factors have contributed in recent years to the solution of the problem of sending electric power economically over great distances: improvements in insulators and improvements in conductors. In the early days of electric power transmission the "pin" type insulator limited the line voltage, as I have mentioned, to about 66 kV. Copper conductors were used in all lines and with such a voltage they had to be of large sectional area in order to avoid undue losses. This meant that what may be called the economic radius of a generating station was comparatively small: if transmission lines were made longer, overhead costs made it impossible to supply power at a price attractive to the user. Improvements in the design and construction of insulators more than trebled the maximum safe line voltage, with a consequent reduction in the sectional area of conductors, though it must be remembered that for a given high-tension voltage the thickness of the conductors cannot be reduced below a certain definite figure if serious losses from corona effects are to be avoided. Then came the invention of the steel-cored aluminium conductors. Not only is this cheaper than copper, but it has also greater tensile strength: spans can be longer and, therefore, fewer pylons are needed.

The Future

In days to come I have no doubt that electric power will be conveyed economically over far greater distances than we wot of to-day. Possibly such a development won't affect this small country enormously—though one wonders what bearing it may have on the future of the electric scheme for the Highlands of Scotland, which can rely on vast and hitherto untapped resources of water power. But in many other parts of the world it may lead to developments undreamt of to-day. Even here it may bring us to utilise for heating, lighting and industrial purposes sources of power that are at present running to waste. Have you, in your travels in these islands, ever seen the Falls of Lora at Connell Ferry, near Oban? There must be a vast amount of power available here.

Letters to the Editor

In Support of the Wire · 10 kc/s Separation? Pick-up Filters

Wire versus Wireless

HAVING had some years' experience in broadcast relay over wires, which is akin to wired broadcast, besides in radio service and sales and, at present, radio manufacturing, perhaps I may be permitted to make a few observations on the subject?

First, neither your Brains Trust members nor your Editorial provide very solid arguments against P. P. Eckersley's proposals. You all seem concerned with the fact that wired broadcast will be controlled by the Government or other dictatorial body (surely this is true of open broadcast at present?) and, judging by some of your remarks, none of you seem to have much faith in the democratic Governments *you* will elect in this "new" world!

Secondly, much is made, by those in favour of open broadcasting, of the enormous number of programmes available on an all-wave set (with or without interference, fading, etc.!). (Yes, Madam, Timbuctoo easily on an indoor aerial!) Go into nine houses out of ten (ours included) on any day and what will you find grinding out of the loudspeaker? Either the Home or the Forces programme! As far as I can see, it makes little difference whether the Home or Forces is coming over the air or by wire—except that by wire the reception would, in many cases, be better.

Thirdly, I think I detect, in those who argue against wire broadcasting, a somewhat shaky feeling as to what would happen to the radio receiver market and their future positions, should wire broadcasting come to stay. Personally, I think anything would be better than the Awful Mess that was known as the "Radio Trade" in the latter pre-war years!

Fourthly, to summarise: in my opinion Eckersley has stated well the case for wire broadcasting, but there are, of course, difficulties in initiating the service and, for the immediate future, it seems to me the best thing is (as usual) compromise. Provide receivers which operate on either wired or open broadcast, also television, reducing, where possible, the number of radiating broadcast stations on the various wavebands. D. W. HEIGHTMAN.

Clacton-on-Sea, Essex.

I READ last month's Editorial, and also the views of your "Brains Trust" on that much mooted question "Wired Broadcasting—or Not"! In the first place I am disappointed that the Brains Trust feature should be used for political discussions, not because it was any the less interesting, but while I respect the technical opinions of your contributors, I feel that they are in no way qualified to talk politically. In fact, having read what they have to say, I am more than ever inclined to think favourably of the scheme as outlined by P. P. Eckersley.

Two red herrings would appear to have crossed the path of unbiased technical discussion on this subject, namely: (a) What effect will the introduction of wired wireless have on receiver sales? and secondly: (b) We shall be entertained, educated and "propagated" on the lines laid down by the Government, and that we are to be precluded from hearing the numberless contrasting views put out by the rest of the nations of the world.

With regard to (b)—what utter nonsense!

I cannot see why *both* systems should not exist side by side. I think, moreover, that if some of the programmes were transferred "underground," that more room would be available in those already overcrowded wavebands for that "infinite variety of programme material which will emanate . . . after the war." (And with a better chance of hearing it too!)

Perhaps your contributors would show how "the Government" does not now influence the matter radiated by that great monopoly, the British Broadcasting Corporation; or rather, which is perhaps more important, how we should be any the worse off politically if the B.B.C. did feed some of their programmes over wires instead of "over the air."

There has never been any question that ordinary radio broadcasting should be given up for wire broadcasting even less so that the household set should be "purged" and a ban placed on foreign listening. Coming back again to the first bogy, I believe that the system should be introduced and that manufacturers should produce a unit to detect the "wired" signals, employing the ordinary household set as an amplifier. In due course a set could be sold which would combine the detection and tuning unit with the normal all-wave receiver.

No! I cannot see any justification for the sombre views expressed on the outcome of the effects, both politically and technically, of the introduction of "wired wireless."

J. GIBBONS-PARTRIDGE.

Lower Castlereagh, Co. Down.

I CONSIDER your attack on the G.P.O. and your arguments against "wired wireless" entirely ill considered; your Editorial and "Brains Trust" contributions carry all the stamp of Left Wing hysteria. There is no connection between a Nazi workshop and a democratic home. In a democracy a person is free to buy the form of broadcasting receiver he fancies, and can subsequently switch off any programme he dislikes, so that if his receiver emits unwanted opinions or noises, he has the remedy!

Furthermore, to state that distance-getting is the greatest "magic" of broadcasting receiving is entirely to ignore the facts. My experience in hundreds of homes has proved to me that the public in general do not "listen-out." The station-getting facilities were entirely wasted. When Radio Normandie and Luxemburg were available, seven out of ten sets appeared to be permanently tuned to them; two of the other three listeners were concerned mainly in not missing Henry Hall's programme, and the odd one was generally a quality fan who used Continental programmes only when there were no "Proms." Short waves were not understood, and in any case were too difficult for most people.

In conclusion, I affirm that the public can get all they want, including quality, from wired broadcasting without paying exorbitant prices for complicated competitive apparatus they cannot use, and I think it is this fact that is causing misgivings amongst those mainly concerned with unloading so-called "new" models year by year by means of the "hot salesmanship" of which ›u accuse the G.P.O.

H. F. LESLIE.

London, N.W.7.

Post-war Broadcasting

I WOULD like to put forward a suggestion which I have never seen mentioned so far. It is simply to standardise the spacing of transmitters in Europe at 10 kilocycles.

The advantages of this are many. First, perhaps most important, heterodyne interference is almost entirely eliminated—as anyone who has operated a receiver in the U.S.A. or Australasia can testify. Chance heterodynes between transmitter harmonics, etc., are never less than 10 kc/s. Secondly, the fidelity of the reception can be slightly improved. Thirdly (another important reason), it would bring Europe into ›e with the U.S.A., Canada, ›ath and Latin America, Australia and New Zealand. About two-thirds of the world's transmitters are located in these countries, which all have 10-kc/s spacing. Fourthly, since we already think in decimal terms of kilocycles, megacycles, etc., it would be much more convenient if the stations were spaced decimally, and had frequencies such as 660, 1210, 9,340 kc/s. Fifthly, it would simplify the calibration of receivers and identification of transmitters. This may seem an unimportant point, but if a dial is divided by radial lines, each spaced 10 kc/s, as they often are, then a station will always be tuned in on one of these lines. Then, if an unknown transmission is received, its *exact* frequency can be read off even if the receiver is mis-calibrated by ±3 or even ±4 kc/s, since its frequency will be that of the nearest 10-kc/s mark. At present the dial must be calibrated accurately to ±0.4 k/c (or 400 cycles) at least, to find the exact frequency of a station.

Now, if ever, is the time to prepare for this change—a change which is essential if post-war broadcasting is to run smoothly.

P. D. THOMAS.

Ayr.

"Visual Frequency Comparison"

WE notice that the August issue of *Wireless World* contains an article describing the use of a "magic eye" tuning indicator as a frequency comparator. We would like to place on record that this method has been used in our GM2304 audio oscillator since early 1938.

A. W. RUSSELL,
The Mullard Wireless Service Co., Ltd., Measuring Apparatus Section. London, W.C.2.

[It should perhaps have been emphasised that the use of a magic eye for frequency comparison is in itself not novel. Implied claims for the novelty of the method described by our contributor rest on the inclusion of means for obtaining reliable indications up to the 12th harmonic.—ED.]

"Static Charges on Records"

MY note on this subject (p. 165, June *Wireless World*) has provoked a number of enquiries regarding the best method of overcoming the difficulty of the removed coating thread tending to fly up against the cutting-head, causing tangling with the stylus, etc. The recognised means of thread control are, of course (a) hand-brush, (b) automatic brush or chip-chaser, (c) suction device (see p. 137, May, 1941, *Wireless World*), and a method, used in some professional studios, of covering the blank about five minutes before being cut, with a solution consisting chiefly of distilled water, and leaving to dry. To facilitate coating the blank evenly, it is necessary to reduce the surface tension of the water, and to give it conducting properties, other ingredients have to

Letters to the Editor—

be added. These can be a proprietary detergent, e.g., "Aquasol" (1 drop in 0.25 pint), or a minute quantity of high-grade soap (the residual saponified oil that will appear on the record surface, although not improving its appearance, may actually prove useful as a slight lubricant), plus a trace of colloidal graphite. Exact formulæ have not been published, but experiments on the lines indicated (I acknowledge gratefully Dr. C. G. Lemon's advice in this connection) will prove well worth while. This treatment must be applied only to lacquer-coated blanks, never gelatinous coatings. Incidentally, some recordists use a hard stream of cold water for removing dust or foreign matter from the blank surface, rather than the usual brush, when the best medium—compressed air—is not available.

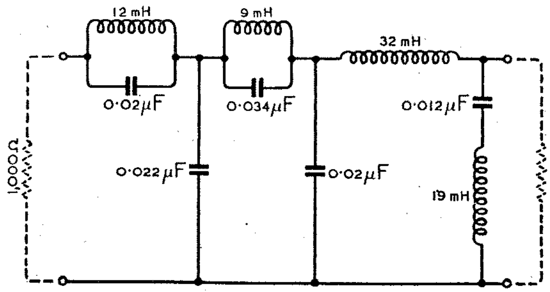
Finally, may I suggest that, following on the recent interesting pick-up designs, a fruitful field for experimentation is the design and construction of high - quality electro-magnetic and crystal disc cutting-heads? Details of a really good head design would be greatly appreciated by recordists.

DONALD W. ALDOUS.
Torquay, Devon.

Pick-up Filter Circuits

I WAS very interested by Mr. Brierley's article in your April issue on a filter for use with a high-quality pickup. Such a filter would also be useful in a local-station receiver to remove 9 kc/s heterodyne whistles, especially if the resonant frequency of one shunt arm is made 9 kc/s. However, in its present form it has several disadvantages, particularly its bulk, the compromise between hum and screening, and the difficulty in obtaining the wire at the present time.

By using a low-impedance filter all these disadvantages are overcome. It can then be worked from an "infinite impedance" detector, the output impedance of which is about 600Ω for an ordinary medium amplification factor triode. The "Gram." side would pass through a bass compensator and an amplifier into a cathode follower and thus to the filter.

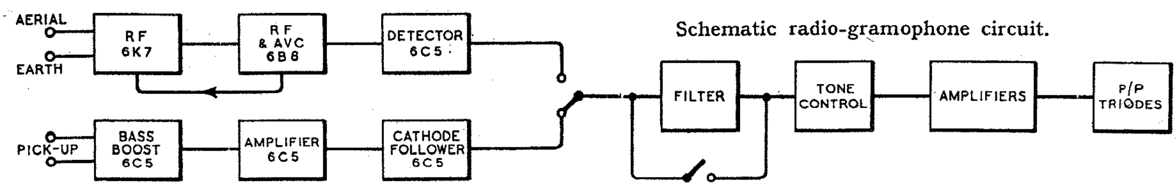


Suggested filter for 1,000-ohm load.

This has the additional advantage that the gramophone amplifier can be kept entirely separate from the rest of the circuit if required, the low impedance preventing any pick-up in the long leads.

I have calculated the values for a filter fulfilling these requirements, but unfortunately I cannot at present undertake any practical experiments, and I should be very glad to have any readers' opinions. The suggested circuit is also shown, it being arranged that the filter can be shorted out when on radio, but is permanently in on gramophone.

M. E. FELIX.
Cranwell.



Schematic radio-gramophone circuit.

Frequency Modulation

THE advocates of the frequency modulation system for normal broadcast reception continually stress its main advantages as being absence from interference noises, and better quality reproduction, and it has been put over on these grounds in America. The writer, who has been interested in obtaining what we used to call "nearly perfect reproduction" for a number of years, would like to suggest that we are still a very long way, at least in the case of the ordinary sets commercially available, from taking full advantage of the quality possible with the normal amplitude modulation system now in use, and that, therefore, this claim for frequency modulation, which is due entirely to the use of short waves which are equally applicable to amplitude modulation, is in the nature of a red herring.

It is to be observed, too, that in this country the writer's experience shows that outside interference with reception is rarely serious except when listening to distant stations, for which purpose, of course, the frequency modulation system is unsuitable.

JOHN BAGGS.
Saddleworth, Yorks.

SERVICE-MEN'S EXAMINATION

Draft Syllabus Issued

AS we first reported some months ago, plans have been made for the conduct of an examination in wireless maintenance and repair. To this end, the Radio Trades Examination Board was formed, with the function of conducting the examinations and awarding Radio Servicing Certificates to successful entrants. The Board comprises three representatives each of the Radio Manufacturers' Association, the Scottish Radio Retailers' Association, the Radio and Television Retailers' Association and the British Institution of Radio Engineers.

A draft syllabus of the proposed examination has now been issued by the Technical Committee of the Board and is printed below.

Part 1.—Fundamental Principles of Radio.—(1) Current/Voltage relationships in AC and DC circuits. (2) Theory of magnetism: magnetic screening. (3) Laws of induction: mutual and self-inductance. (4) Electrostatics: electrostatic screening. (5) Resonance: series and parallel resonant circuits. (6) Modulation, methods of. (7) Thermionic valves. (8) Rectifiers: rectification and detection. (9) Electromagnetic waves: simple wave theory. (10) Aerials and transmission lines. (11) Amplifiers and oscillators. (12) Receiver circuit practice. (13) Reproducers and electrical pick-ups.

Part 2.—Practical Applications.—(1) Principles and use of test meters: resistors; rating and coding. (2) Permanent and electro-magnets, and their uses. (3) Transformers, RF, IF, AF, and mains. (4) Condensers, variable and fixed. (5) Tuned circuits and alignment. (6) Diode, triode, tetrode, pentode and frequency-changing valves: gas-filled types. (7) Copper-oxide and selenium rectifiers: methods of rectification; simple filters; battery-charging plant. (8) Receiver power supplies. (9) Wave propagation: interference and its suppression. (10) Aerial installation and coupling devices. (11) RF, IF, and AF amplifier circuits. Degeneration and regeneration: negative feed-back, oscillators. (12) Public-address and relay practice; methods of mixing; reflex circuits. (13) Receivers: TRF, supersonic heterodyne and super-regenerative. (14) Automatic gain control; tuning indicators; automatic frequency control; automatic tuning devices. (15) Tone control and correction circuits; noise suppression circuits. (16) Loudspeakers, microphones and gramophone pick-ups. Methods of matching.

Part 3.—Practical Examination.—(1) Soldering technique. (2) Care and maintenance of tools and instruments. (3) Valve testing (HT, LT and GB supplied). (4) Correction of typical receiver faults, which may include re-alignment. Circuit diagrams, chassis layouts and oscillators supplied. (5) Testing components.

AIR RAID WARNINGS

Valve Equipment for "Imminent Danger" Signals

TO meet the danger from surprise enemy attacks the local authorities at Hove have installed their own system for warning the townspeople. This consists of a valve-generated signal tone which may be distributed from an 800-watt amplifier to loudspeakers in various parts of the town. The valves are kept running continuously and facilities are provided for checking valve efficiency.

The amplifier may be used to re-inforce normal Home Office "Alert" and "All Clear" siren tones and also for police announcements, but the Imminent Danger Signal automatically takes priority over any other input.

The equipment was made by the G.E.C. and supplied and installed by Broadcast Amplifiers, Ltd., 17, Preston Road, Brighton.

GOODS FOR EXPORT

The fact that goods made of raw materials in short supply owing to war conditions are advertised in this journal should not be taken as an indication that they are necessarily available for export

RECENT INVENTIONS

A Selection of the More Interesting Radio Developments

FRAME AERIALS

THE presence of a mass of powdered iron inside the field of a frame aerial is stated to increase the pick-up and sharpen the directivity of the aerial, provided the spacing of the windings is suitably correlated with the "grain" of the powdered magnetic material.

The magnetic "core" is preferably arranged symmetrically about the axis of rotation of the frame, though some degree of asymmetry may be deliberately introduced in order to correct for the quadrantal or like error due to the presence of a nearby conductor.

In one arrangement the core consists of a hollow cylinder, built up of a number of rings, set close to the frame windings and concentric with the aerial shaft. Alternatively, the core may consist of a hollow sphere of powdered material about which the frame windings are mounted to rotate.

Standard Telephones and Cables, Ltd. (communicated by W. J. Polydoroff). No. 551546. (Addition to 522492.)

FREQUENCY MODULATION

THE repetition frequency of a multivibrator oscillator, comprising a pair of cross-coupled valves, depends upon the time constant or resistance-capacity value of the coupling circuits. Since this includes the anode-cathode resistance of each of the valves, any factor which varies the valve resistance will alter the output frequency of the oscillator as a whole. If then the multivibrator is normally designed to oscillate at a carrier-frequency, the application of a signal voltage to the anode or grid circuit, or to one of the electrodes of each of the valves, will give a frequency-modulated signal.

The signal input may be applied through parallel amplifiers to the anode or grid resistances or directly to the screen grids of each of the valves forming the multivibrator pair. The frequency-modulated output is taken off from a coil which is inserted between the two anode resistances and centre-tapped to the common high-tension supply.

Marconi's Wireless Telegraph Co., Ltd. (Assignees of G. L. Usselman). Convention date (U.S.A.) October 30th, 1940. No. 552039.

TUNING TO FM SIGNALS

A VISUAL tuning indicator is generally required to ensure the accurate adjustment of the circuits when receiving frequency-modulated signals, particularly when these are transmitted on the ultra-short waveband.

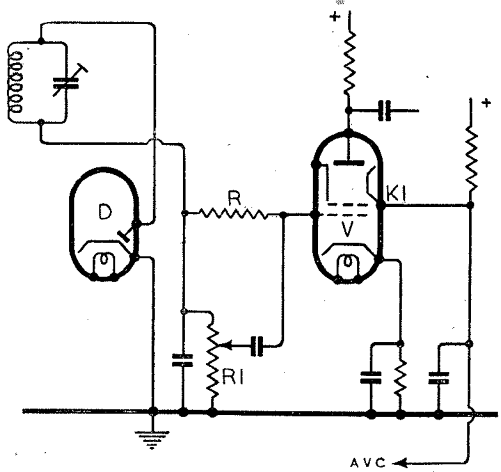
In order to allow of accurate tuning by the ear alone, the set is fitted, according to the invention, with a magnetic relay which automatically keeps the signal channel to the loudspeaker open-circuited until the threshold of accurate resonance has been reached, whereupon the relay is closed to allow the required signals to come through. Incidentally, the arrangement also serves to cut out undesirable inter-station "noise."

The relay is subjected to the pull of two coils arranged in opposition. One coil is fed with rectified grid current from the limiter valve, and the other coil is energised from the frequency discriminator circuits. As the point of accurate resonance is approached, the current through the second coil falls off, and the pull of the first coil predominates, thereby bringing the loudspeaker into action.

Marconi's Wireless Telegraph Co., Ltd. (Assignees of D. E. Foster). Convention date (U.S.A.) October 25th, 1940. No. 552462.

AUTOMATIC CONTROL

PROVISION is commonly made in a wireless receiver to develop a control voltage which can be used either for AVC, or for adapting the bandwidth of the set to the prevailing interference, or for automatic tuning, or for expanding or compressing the frequencies in the AF stage. The derived voltage is preferably amplified in order to improve the effective control. As it is necessary to maintain correct polarity, this usually involves the addition of at least one phase-reversing valve.



Secondary emission control circuit.

To simplify the phasing problem, use is made of an amplifier comprising a secondary-emission cathode.

As shown in the figure, the valve V contains an electrode K1, the emission from which varies with the intensity of its bombardment by the main discharge through the valve. The control voltage is generated by a diode D, coupled as usual to the IF stage (not shown), and is applied through a resistance R to the control grid, which also receives rectified signal voltages from a tapping on a resistance R1. The potential of K1 varies with the secondary emission from it. This depends upon the electron impact of the main discharge stream, which, in turn, is controlled by the applied grid voltage. The signal output is taken from the anode, and the AVC voltage from the electrode K1.

For "contrast" control, K1 is directly coupled to the screening grid of the last LF amplifier.

Philips Lamps, Ltd. (communicated by N. V. Philips Gloeilampenfabrieken). Application date July 29th, 1941. No. 551981.

SHORT-WAVE SIGNALLING

SHORT-WAVE signals reach their destination by alternative paths which vary in length according to the manner in which the radiated energy is reflected from the ionosphere.

When sending morse signals by the known method of using "spacing" and "marking" pulses which differ slightly in carrier-frequency, the phase-differences mentioned above produce beat-notes at the beginning and end of each significant pulse, which tend to blur the definition of the morse.

To overcome this difficulty a momentary "overswing" above and below the normal frequency is deliberately introduced in transmission, at the beginning and end of each marking and spacing wave respectively and for a period which corresponds approximately to the longest time-delay which is likely to be produced as a result of the multi-path propagation of the signals.

This increases the average frequency of the undesired beat-notes during their persistence, and, in the simplest form of the invention, allows them to be more easily filtered out. Alternatively, it permits of a higher keying speed for a given ratio of signal strength to beat interference.

Marconi's Wireless Telegraph Co., Ltd. (Assignees of C. W. Hansell). Convention date (U.S.A.) November 23rd, 1940. No. 552068.

The British abstracts published here are prepared with the permission of the Controller of H.M. Stationery Office, from specifications obtainable at the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1/- each.