

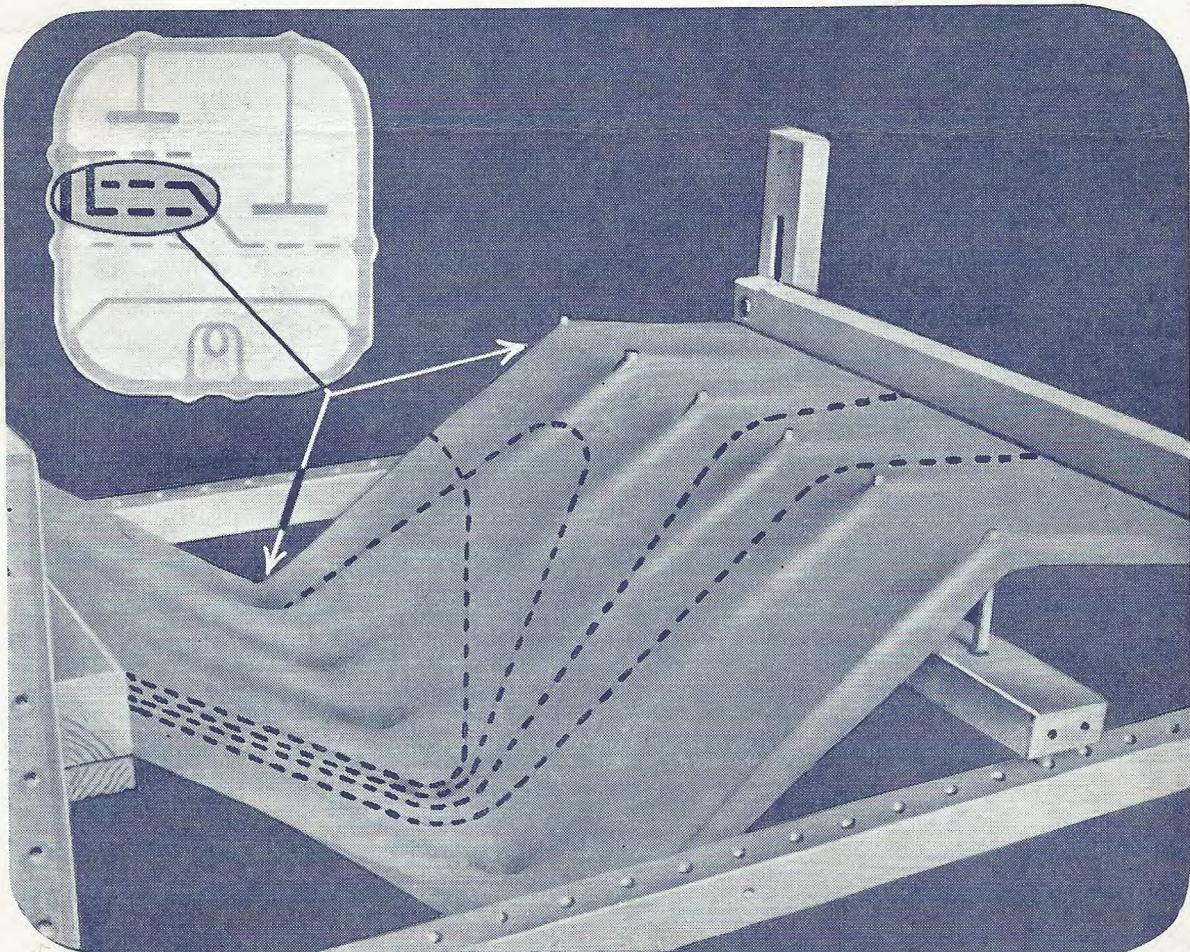
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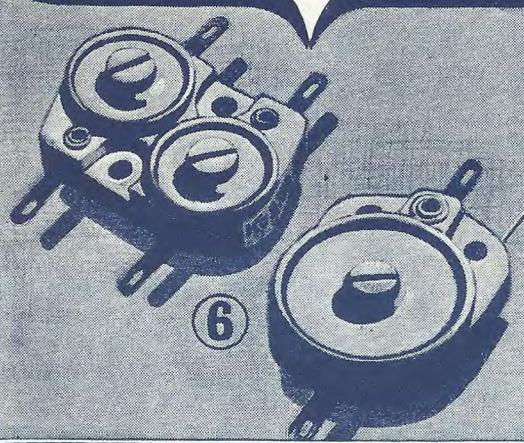
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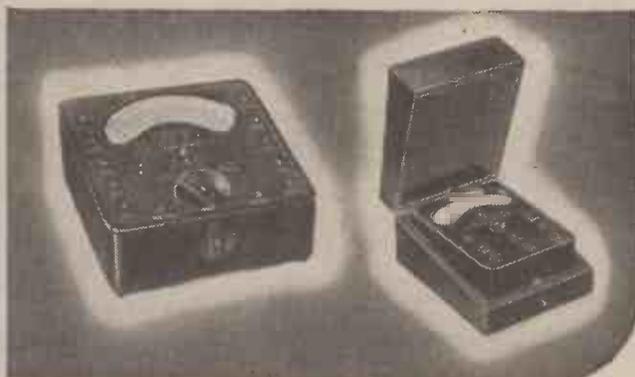
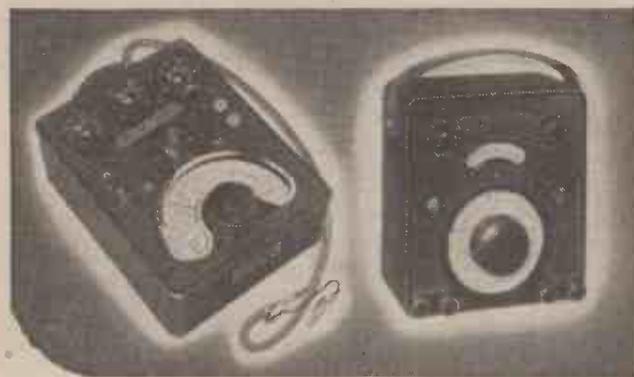
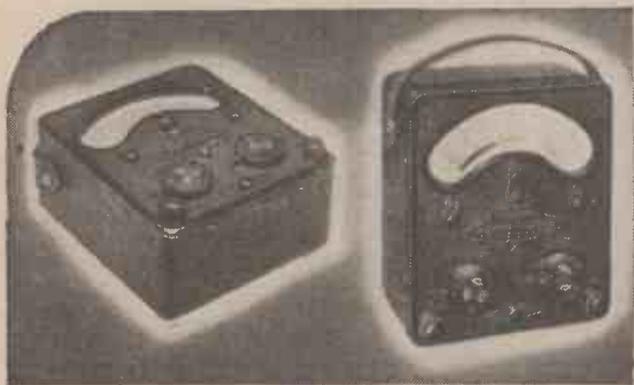
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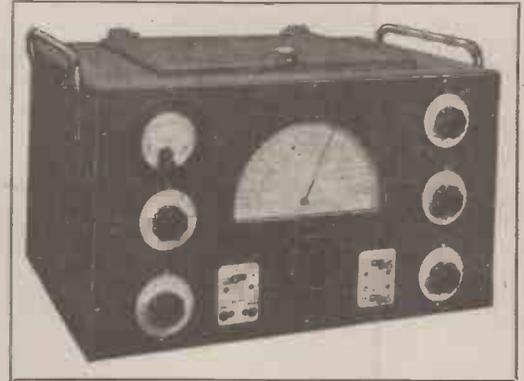
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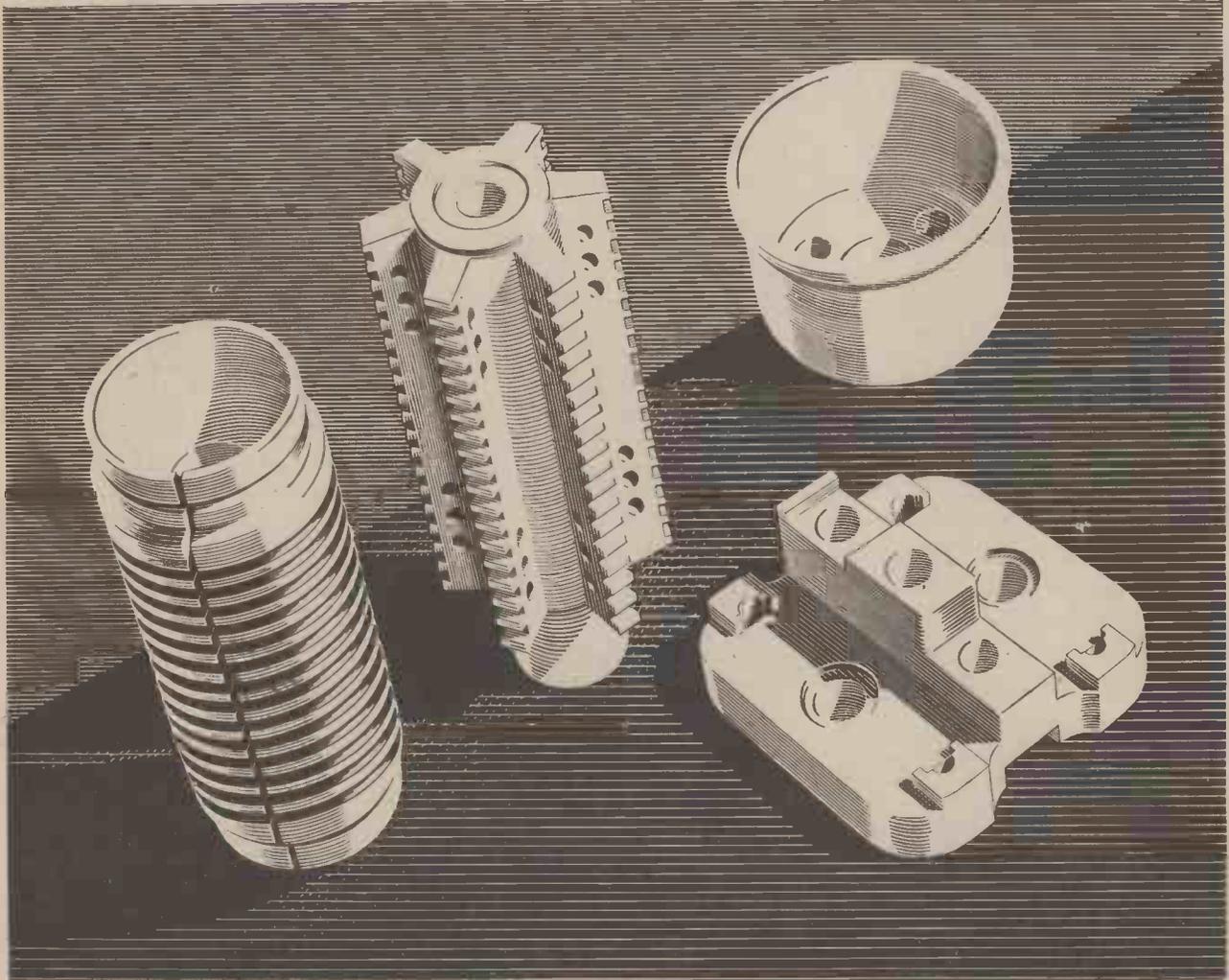
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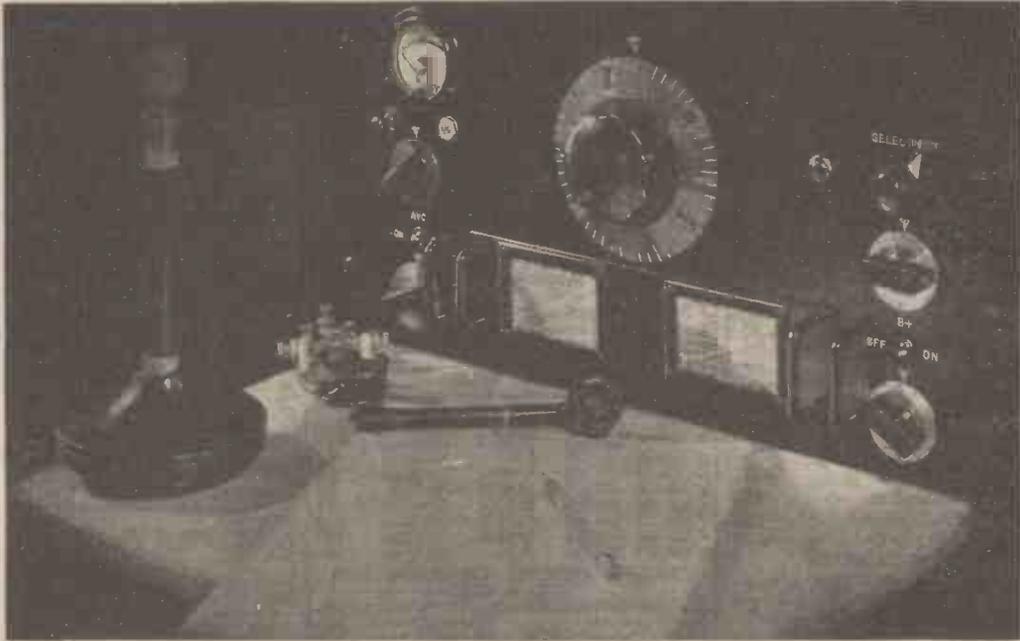
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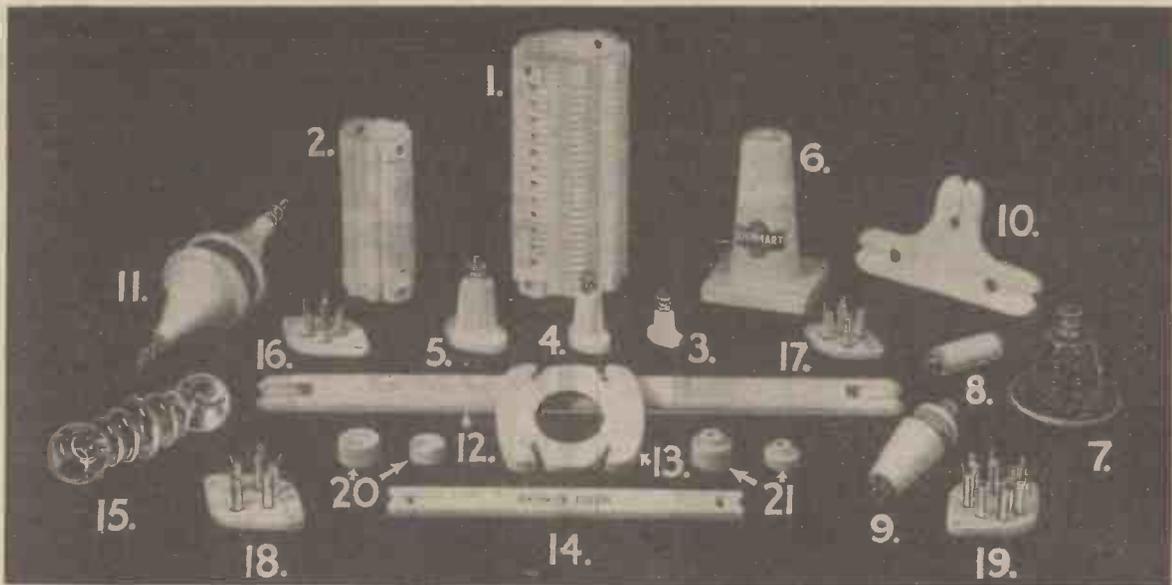
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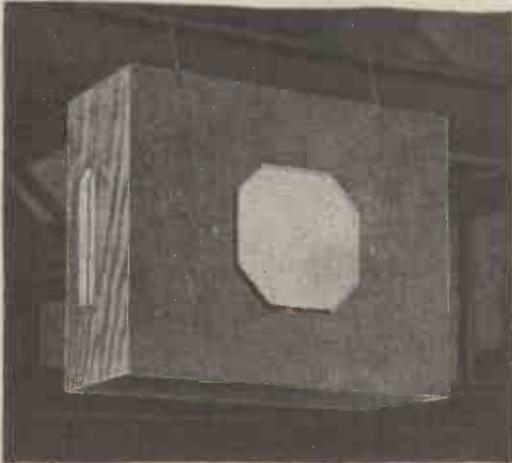
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## Under-trained Service-men

### *A Second Chance for the Radio Industry*

IN the early days of wireless many of those who entered what was then a brand new vocation managed to "pick up" a superficial but sufficient knowledge of its technicalities without any real background of knowledge and without any study of fundamentals. That is no disparagement to the pioneers: the field for development was then so wide, and wireless apparatus so simple, that it was possible to make valuable contributions to progress, to say nothing of performing one's routine tasks, without possessing any deep basic knowledge.

There are exceptions to every rule, but, broadly speaking, the day when a man without training in the fundamentals of wireless can "hold down" a technical job is over. This point was well brought out when Mr. Edward Rosen, speaking at a recent meeting of the Radio Industries Club, declared in the most forthright manner that the training of those responsible for the maintenance of broadcast receivers was inadequate. Mr. Rosen did not lack the courage to condemn the industry of which he himself is a prominent member, and roundly stated that television, firmly established as a public service just before the outbreak of war would ultimately have failed for the lack of adequate servicing. He went on to say that it has been found necessary for service-men entering the Forces to be given extensive extra training before they were able to do useful work in their trade capacity.

#### *Unpalatable Truths*

These are serious statements, unpalatable to most of us, but, much as we would like to be able to controvert them, there can be no doubt of their essential truth. Those service-men who have succeeded in their difficult vocation—and we have the highest admiration for them—have done so by virtue of exceptional mental qualities rather than

as a result of training. Alertness, power of deduction and logical thinking, all necessary qualities for wireless servicing, are perhaps things that cannot be taught, but are in themselves insufficient without a background of fundamental knowledge. Each advance in the complexity of our technique adds force to the truth of this statement, and one is driven to the conclusion that it is wrong to expect those who have gone straight from school to the service bench to undertake the maintenance of elaborate broadcast sets, to say nothing of television receivers.

The question of general education, as distinct from specialised training, also enters into the matter. It is strongly urged that the majority of wireless students need a better grounding than they generally possess when they begin their career as specialists.

#### *An Opportunity to be Grasped*

A second chance to rectify a fault or omission is something that is seldom given to us. But in this matter we are lucky enough to have it for the taking. As Mr. Rosen pointed out, thousands of service-men are undergoing a first-class technical training in the Services; it behoves the wireless industry to make plans now for using their services to the best advantage when peace returns. And, let us add, not only the industry but also the general public, which eventually pays the bill must be prepared fairly to reward the laboriously acquired knowledge and qualities of mind that are needed in a good service-man. Broadcasting is vital to our national life, and television will become so. Service-men fully capable of playing their part in the maintenance of these services deserve more generous recognition and a higher status than they have hitherto enjoyed.

# Frequency Changing

By JAMES GREIG, Ph.D., M.Sc. A.M.I.E.E.

**N**OW, more than ever before, the fundamentals of radio engineering are being taught intensively both to men in the fighting services and in the radio industry. It is in such circumstances that the need for simple and, if possible, non-mathematical developments of many important points of radio theory becomes particularly emphasised.

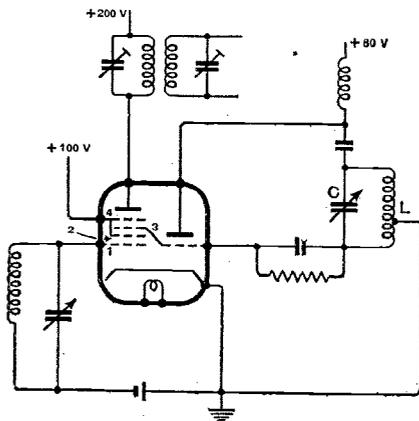


Fig. 1.—Typical connections of a triode hexode frequency changer stage.

One such subject which necessarily receives much attention these days is that of the frequency changer. It is the purpose of this article to develop an approach to the theory of the hexode type of frequency changer valve which has been found helpful to students with limited mathematical equipment.

The hexode frequency changer is a valve in which the electron stream from cathode to anode is influenced by the potentials of four grids, two of which are screens of fixed potential, while the remaining two are control grids and carry alternating potentials. Very commonly there is associated with the hexode a small triode oscillator mounted on the same bulb and directly connected to one of the hexode control grids. A common circuit arrangement for a hexode frequency changer stage is shown in Fig. 1. It will be seen that the incoming signal is applied to grid 1 (nearest the cathode). Grids 2 and

4 are screens having a common fixed potential. Grid 3 is internally connected to the grid of the triode which is connected to an oscillatory circuit, LC, as a conventional Hartley oscillator (the "local" oscillator). This grid, usually termed the modulator grid, therefore carries the same bias voltage and alternating "swing" as the grid of the triode. The external anode circuit is tuned to the intermediate frequency (IF) of the set.

The function of the frequency changer may be stated as that of transferring any wanted signal from the carrier upon which it is picked up to a new carrier of fixed frequency (the intermediate frequency of the set) upon which it will undergo amplification and finally rectification in the subsequent stages of the set. The problem now is to understand how the valve effects the transfer of the wanted signal to the intermediate frequency.

The proper starting point is the static valve characteristics, Fig. 2. Let us first (having applied appropriate anode and screen voltages) fix the potential of the modulator grid 3 at a suitable value, say  $-10$  volts, and then vary the voltage on grid 1 from a large negative value to zero, observing and plotting the anode current for each grid voltage. The result will be a curve such as curve 1, Fig. 2. Let the process be repeated for two other fixed values of  $V_{g3}$ , say

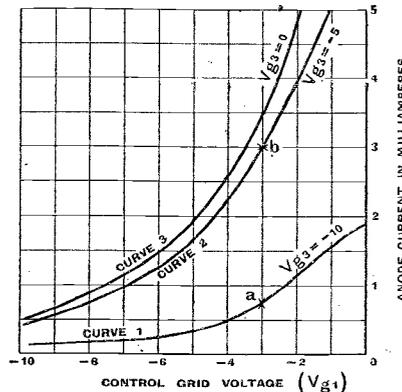


Fig. 2.—Static characteristics of the hexode for various values of modulator grid potential.

## A Non-Mathematical Approach to the Theory of the Hexode

$-5$  and  $0$  volts. With these values curves such as curves 2 and 3 will be obtained. It will be noted that the steepness of the curves increases as the negative bias on grid 3 is diminished. This change of slope is the significant factor in the frequency changing property of the valve.

### Electron Paths

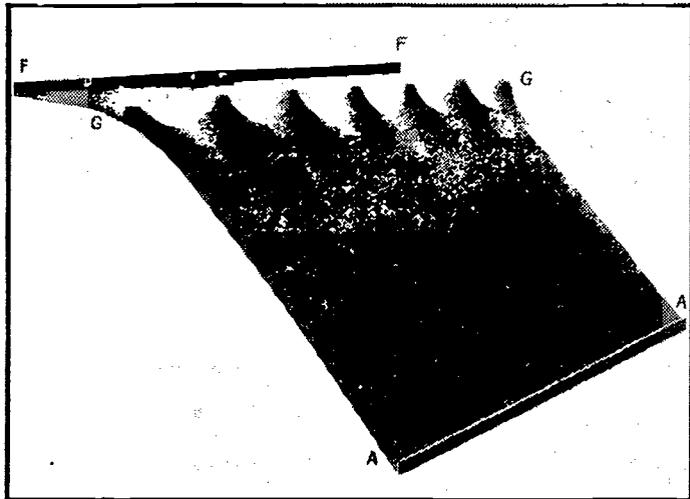
It will be instructive to consider first, in a simple physical way, how the change in slope arises. This is most readily done by visualising the paths taken by electrons in their passage through the valve. Now the mechanics of electrons in electric fields is closely similar to that of bodies in gravitational fields and, in fact, electrons undergoing attraction to a positive electrode correspond exactly to balls rolling down a slope, while conversely, previously accelerated electrons approaching a negative electrode correspond to balls rolling uphill. A mechanical model of a valve may, as we shall see, be made by stretching a rubber sheet over which steel balls, representing electrons, may be rolled, in a particular "uphill downhill" configuration to correspond to the electrode geometry of the valve and the various electrode voltages. Such models are sometimes used by manufacturers in valve design work.

Take first the case of a triode. A model of a triode is illustrated in Fig. 3. The rubber sheet is stretched between two rails FF and AA, which correspond to the filament and anode of the valve respectively. In be-

tween, in the same relative position as the grid in the actual valve, is mounted a rail with a row of prongs, much like an upturned garden rake. These prongs represent the grid wires (their diameters and spacings corresponding) and, as the rubber sheet is stretched over the prongs, it takes up the form shown in the figure. Now electrical potential difference or voltage corresponds in

iveness of the grid to the effectiveness of the anode in controlling the electron stream, the way in which this ratio depends upon the position of the grid and the spacing of the grid wires can be seen at a glance from the model. If, for example, the grid is set so that, for a particular anode voltage (i.e., depth of AA below FF), electrons just do not run away from any point on FF, a very

the corresponding momentum will ascend the slope towards the negative grid, but in general they will "take the hill" obliquely, having been deflected by the depressions, except where the electron happens to pass exactly through the middle of a "window" of grid 2. Typical electron paths are shown by the dotted lines on the rubber surface. The path AA represents that of a ball rolling freely from A and passing midway between two of the positive grid wires. Balls starting from B, C or D, passing progressively closer to a depression, are turned aside by "running round" the depression. To make the model complete there should be holes at the bottom of each depression into which electrons heading straight for a grid wire would fall, such electrons representing those intercepted by the actual grid wires.



Mechanical model of a triode valve with rubber sheet stretched to represent the potential distribution between filament, grid and anode.

## Space Current

Referring to the valve characteristics, consider a change of  $V_{g1}$ , from say  $-3$  to  $-2.5$  volts. On curve 1 ( $V_{g3} = -10$ ) this would result in a change of anode current of  $0.2$  mA., whereas on curve 2 ( $V_{g3} = -5$ ) the increase in anode current would be  $0.5$  mA. Now the signal grid (grid 1) and the first screen (grid 2) behave exactly as in a normal screen grid valve, so that the space current leaving the cathode will depend entirely on the potentials of these two electrodes and not on the potential of any electrode lying behind the first screen. Thus, with a given increment of  $V_{g1}$ , there will be a definite increment of the space current arriving at and passing through the first screen.

The next grid which the electrons encounter, grid 3, is at a negative potential and the electrons, having been accelerated to a considerable velocity in "running downhill" to the first screen, will now be running uphill against the negative potential of grid 3. Not all the electrons which approach this barrier will surmount it. Those which do, pass on to the next screen and anode, those which fail fall back into the first screen. The fraction of the total oncoming stream of electrons which surmounts the barrier of grid 3 depends on the

the model to difference in level. The rail FF, corresponding to the cathode, is at the zero of potential and the drop in level between FF and AA represents the anode voltage, i.e., the greater the anode voltage the bigger the drop. Similarly, the level of the tops of the prongs corresponds to the grid voltage, so that if the grid is negative, the tops of the prongs will be above the level of FF. The shape of the stretched rubber sheet represents what is called the "potential distribution" inside the valve; and the effect of the electric field in the valve on an electron emitted from the filament will correspond with that of gravity on a small ball rolling freely from FF. The two steel balls shown in the figure represent electrons emitted from the filament. It should be mentioned that the potential distribution represented by the rubber sheet corresponds, strictly speaking, to that with negligible space charge. Such a model illustrates vividly the amplification factor of a triode. Recollecting that the amplification factor represents the ratio of the effect-

small lowering of GG will set the electrons away, but with the grid fixed at the original level a much greater lowering of the anode level would be required to stretch the sheet sufficiently between the prongs, i.e., in the grid "windows," to allow the electrons to run.

## Positive Grids

A model of a positive grid followed by a negative one is required to illustrate the action of grids 2 and 3 in a triode-hexode. A positive grid is represented by a row of depressions at a level below that of the filament, so that in the model the sheet must be pulled down from underneath by a series of cords attached to the rubber sheet in the positions of the positive grid wires. Fig. 4 shows a model illustrating the action of a positive grid followed by a negative one. The row of depressions marked 2 represents grid 2 in the valve, while the projections marked 3 represent the modulator grid. Electrons, after running downhill to the positive grid and acquiring

## Frequency Changing—

negative potential of the grid—i.e., upon the height of the barrier.

The two reasons for this are clearly illustrated by the model of Fig. 4. One is, as we have seen, that electrons emerging from the "windows" of a positive screen tend to do so in a diverging stream, those electrons passing near to the mid-points of the windows going straight ahead, while those which pass near the positive grid wires have their paths bent round towards the wires. It is clear that only the "straight ahead" component of velocity is effective in climbing the slope and, depending on the height of the barrier, a portion of the oblique running electrons will fail to reach the top and will fall back into the screen. The other reason is that the top of the barrier is not a level straight line, but is a series of peaks at the negative grid wires, with hollows in between, so that electrons with a given component of normal velocity approaching near the middle of the windows of grid 3 will get over, while those approaching nearer to the grid wires will fail to do so. The electrons surmounting the barrier of grid 3, neglecting the small number picked up by the next screen, grid 4, constitute the anode current. Clearly, if the height of the barrier is reduced, a greater proportion of the total oncoming electron stream will surmount it.

## Change of Slope

Now the mutual conductance of the valve with respect to grid 1 is the slope at any required point of the appropriate characteristic curve of Fig. 2 for the particular voltage on grid 3, i.e., it is measured by the increment of anode current for a small change of  $V_{g1}$  at the point. Whatever the voltage on grid 3, a given small increment of  $V_{g1}$  will give the same increment of the space current passing through the first screen, but if grid 3 is made less negative a larger fraction of the increment will be passed on to the anode. Hence the slope of the valve increases as the bias on grid 3 is reduced. Screen 4 serves merely to give the valve, as a whole, "screen grid" characteristics, i.e., it shields the other electrodes from the field of

the anode, and incidentally renders the anode current practically independent of the anode volts.

Returning to the main problem of how the frequency changing is effected, it is first necessary to state that frequency changing is nothing more than a form of modulation. Modulation, we recall, produces "side" frequencies, and the new carrier to which the signal is transferred is one of the side frequencies produced by modulating the carrier of the wanted signal by the voltage of the local oscillator.

Consider first the conditions existing if an unmodulated carrier of frequency, say, 1 Mc/s, is impressed on the signal grid with the modulator grid held at a fixed potential of -10

peak, i.e.,  $V_{g3}$  is varied sinusoidally from -5 up to 0 down to -10 up to 0 again, and so on. Clearly we shall vary the amplitude of the 1 Mc/s anode current cyclically at the same frequency. That is, the anode current will be modulated by the alternating voltage on grid 3, and if the mutual conductance of the valve varies in proportion to the deviation of  $V_{g3}$  from its mean value, a condition which is approximated in practice, the modulation will be sinusoidal.

## Modulation Products

Normally we think of a modulating frequency as being low compared with the frequency of the current

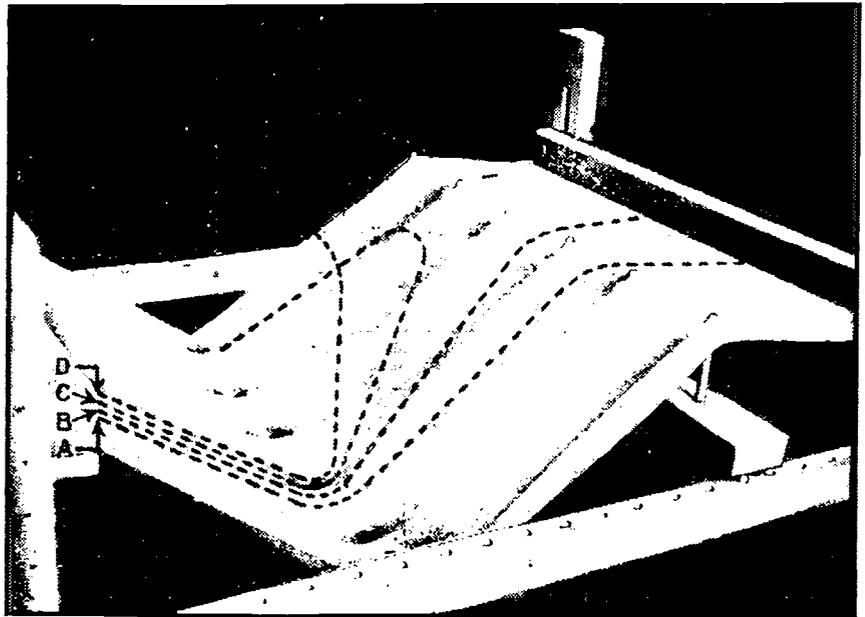


Fig. 4.—Model showing the path of electrons through the positively biased grid 2 and the negative modulator grid 3 in the hexode section of a frequency changer.

volts and a bias of -3 volts on the signal grid. The hexode will then be operating simply as a screen-grid valve and the anode current will be an unmodulated wave of the signal carrier frequency. If now the negative voltage on grid 3 be reduced from -10 to -5, the amplitude of the 1 Mc/s anode current will be increased in proportion to the increase in mutual conductance of the valve, resulting from transferring the operating point from (a) to (b), Fig. 2. Suppose that we fix the bias of grid 3 at -5 volts, but that on this is superimposed a swing of, say, 5 volts

which it modulates, but this is not a necessary restriction, and in frequency changing we modulate by a frequency which differs from the carrier frequency of the wanted signal by the intermediate frequency. Suppose, for example, that our IF is 465 kc/s. If we modulate the received 1 Mc/s wave by a voltage frequency of 535 kc/s from the local oscillator, we shall obtain two side frequencies, one of 1.535 Mc/s and the other of 465 kc/s (the intermediate frequency). If the anode circuit of the valve is tuned to this frequency (465 kc/s), only this com-

ponent of anode current will develop any appreciable volts across the circuit, the other components of current being by-passed. The IF, which is the "difference frequency" between the 1 Mc/s of the signal carrier and the 535 kc/s of the local oscillator is thus, in a sense, the lower side frequency resulting from modulating 1 Mc/s at 535 kc/s.

Now, in practice, we shall be receiving not an unmodulated carrier wave, but one already modulated by a low-frequency signal. Let us consider first the result of changing the amplitude of the incoming carrier wave applied to grid 1, by a fixed amount, say, 100 per cent. The modulator grid is varying the mutual conductance of the valve cyclically at local oscillator frequency and thereby modulating, in the anode circuit, any incoming wave, *to a given depth*, i.e., its amplitude is being increased and decreased by a given percentage. As the depth of modulation of the double amplitude incoming carrier is, therefore, the same as before the actual amplitudes of the side frequency currents will have been doubled (along with the carrier). Thus the amplitude of the difference frequency current in the anode circuit will vary in sympathy with variations in amplitude of the incoming carrier. Regarding the audio signal borne on the incoming carrier as varying the amplitude of the RF wave, we see that the shape of the signal envelope will be reproduced in the amplitude of the voltage developed in the IF circuits.

The modulator grid, in addition to modulating the incoming carrier on grid 1, also affects the anode current directly at local oscillator frequency. Thus, if there were no incoming signal the anode current would have an alternating component of local oscillator frequency only. This remains present when frequency changing is being effected, but in common with the other unwanted frequencies is to a large extent removed by the filtering action of the tuned anode circuit.

### Summary

Regarded in this way, the operation of frequency changing is seen to be essentially a form of modulation in which the modulation is

effected by changing the mutual conductance of a valve which otherwise simply has "screen grid" characteristics. The frequency changer usually has variable- $\mu$  characteristics with reference to the bias on grid 1. The valve thus requires very "long" characteristics so that the signal voltage swings the grid over only such a short part of the characteristics as may be considered reasonably straight. Also the rate of change of mutual conductance with variation in modulator grid voltage should, ideally, be constant over the working range. These conditions can only be approximated in practice and harmonics, and unwanted "modulation products" are always present to a certain extent. The deleterious

effects of such unwanted frequency components are eliminated or reduced to negligible proportions by the filtering action of the band-pass anode circuit which, being tuned to a narrow band about the IF, presents a low impedance to all frequencies lying outside that range.

It is not the purpose of the present article to do more than indicate a simple physical approach to the mechanism of the hexode frequency changer. The term "multiplicative mixing" so often applied to this type of valve arises quite naturally from the mathematical development of the theory, but has probably been the cause of much unnecessary difficulty to beginners in forming a mental picture of the way in which the valve works.

## New Recording Characteristic

### REDUCING NOISE LEVEL

THE frequency characteristic in general use for disc recording is the so-called "constant velocity," in which the amplitude of cut is inversely proportional to the frequency above the cross-over point (varies between 250 and 800 c/s), below which a "constant amplitude" characteristic is used; that is, the amplitude of cut remains constant and independent of frequency with reference to a given input.

A system of pre-emphasis and compensation with what has been termed the "orthacoustic characteristic" has recently been developed, which increases the recorded level of part of the low-frequency range and all frequencies above the cross-over point. This technique is based upon the frequency-energy analysis of speech and music which indicates that low- and high-frequency parts of the audio spectrum normally contain a lower energy level than the portion between 100 and 500 c/s.

This research led to the realisation that both low and high ends of the spectrum could be increased in amplitude on a recording without danger of overcutting at the low end and without producing a too steep waveform for accurate cutting and playback needle tracking at the high-frequency end. Recording these low- and high-frequencies at higher than normal levels and reproducing them at correspondingly lower levels, so that the net result is the same as though no

pre-accentuation had been used, makes possible a reduction in the noise-level of the system.

## E.R.A. Reports

### Thermostat Interference : High-Frequency Resistance

Two Reports on wireless subjects have recently been issued by the Electrical and Allied Industries Research Association, of 15, Savoy Road, London, W.C.2, from where copies may be obtained.

Report M/T67, "Radio Interference from Thermostats in Refrigerators and Irons" is in the form of a statistical survey of the interfering "clicks" produced by typical thermostats. The investigation was carried out with a view to overcoming difficulties in measurements and treatment introduced by the dispersion of the clicks. By S. F. Pearce and S. Whitehead. Price 4s., postage 4d.

Report M/T69, "The High Frequency Properties of Various Forms of Wire Specimens" describes a method whereby the skin factor of conducting wires may be measured at frequencies of 400 Mc/s. Measurements made by the method, which depends upon a thermal effect, show reasonable agreement with calculation for simple non-magnetic wires. Ferro-magnetic wires are shown to have very high skin factors; and the effect of longitudinal unidirectional magnetic fields on the AC resistance of Mumetal, already observed at speech frequencies, are found to persist up to very high frequencies. By G. G. Sutton. Price 6s., postage 4d.

# The Cathode-Follower Stage

## How the Effective Output Impedance is Reduced and Input Impedance Increased

IN essence, the cathode-follower stage is a device to avoid mismatching. It uses a thermionic valve with the load impedance connected in the cathode lead. It was patented<sup>1</sup> by A. D. Blumlein in 1935, and is described in an appendix<sup>2</sup> to the well-known I.E.E. paper on the Marconi-E.M.I. television system.

It is well known that the output voltage of a valve amplifier is developed across a high impedance known as the load, and that if a much lower impedance be connected in parallel with the load (e.g., in the course of coupling the amplifier to the next stage) the gain of the amplifier will be seriously reduced. When an amplifier stage is coupled to a further amplifier, the input impedance of the second stage is connected in parallel with the load of the first stage. The input impedance of the second stage depends upon the frequency. At low frequencies it can be made extremely high simply by the use of such a grid-bias voltage as will prevent the flow of grid-current. At high frequencies, however, it is affected by the interelectrode capacitances of the valve, and is usually fairly low—so low that it cannot be connected in parallel with the load of the first stage without

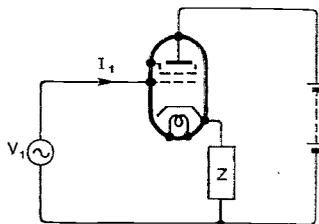


Fig. 1.—Basic circuit of the cathode-follower stage.

unduly reducing the gain of that stage. The bad effect of the grid-anode capacitance of the second stage may be remedied by the use

By EMRYS WILLIAMS,  
Ph.D., A.M.I.E.E.

Developed originally for use in television amplifiers, the cathode-follower stage has since found application in other fields, notably detector circuits. In this article the characteristics of the cathode-follower stage are described and the theory of operation is discussed.

of a pentode or screen-grid valve in that stage. The effect of the grid-cathode capacitance (and the residual grid-anode capacitance) may also be reduced by the use of tuned couplings, in which this capacitance simply forms part of a parallel L-C circuit; but this method may be used only in tuned amplifiers, i.e., where only a single frequency or a narrow band of frequencies is to be amplified. Video-frequency amplifiers in a television system clearly do not come within this category: the frequency range to be handled here is from zero up to several megacycles per second. Thus we are faced with the problem of coupling a second stage, with a low capacitive input impedance, to a first stage which must have a high load impedance.

### No Amplification

In the Marconi-E.M.I. system this is done by interposing between the stages a cathode-follower stage. The cathode-follower stage has a high input impedance, i.e., the output of an amplifier stage may be connected to a cathode-follower without effectively shunting a low impedance across the load of the amplifier stage. Also the cathode-follower has a low output impedance, i.e., the magni-

tude of its output voltage is not affected by connection to the low input impedance of a subsequent amplifier stage. The cathode-follower does not itself amplify; indeed, its voltage amplification ratio is slightly less than unity. In the Marconi-E.M.I. system a cathode-follower follows each stage of amplification, and also is used to couple amplifier stages to low impedance feeders and to monitoring apparatus.

The circuit of the cathode-follower stage is shown in Fig. 1. The input voltage,  $V_1$ , is connected in the grid circuit in the normal way. This

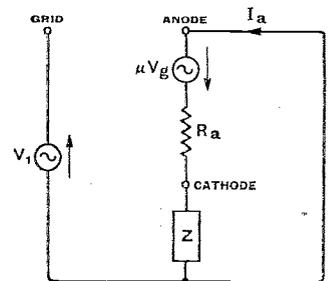


Fig. 2.—Equivalent of the cathode-follower.

voltage is that derived from the previous amplifier stage. The impedance,  $Z$ , in Fig. 1, is shown connected between the *output terminals* of the cathode-follower.  $Z$  represents the impedance of whatever circuit is connected between these terminals, e.g., the input-impedance of the next stage. Of course  $Z$  must provide a DC path for the anode current of the cathode-follower stage; a high resistance may be connected across the output terminals of the cathode-follower, and this resistance may be resistance-capacity coupled to the next stage.

We shall now show that the output voltage does not depend upon having a very high value of the load,  $Z$ , as does the output of an amplifier stage.

Fig. 2 shows the equivalent circuit of the cathode-follower. This equivalent circuit is derived from

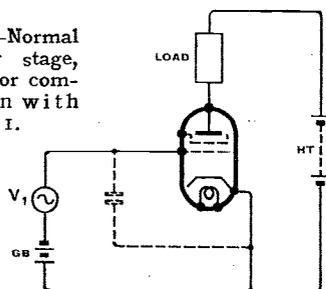
<sup>1</sup> British Patent No. 448421.

<sup>2</sup> J.I.E.E., Vol. 83 (1938), p. 779 and (Wireless Section) Vol. 14, p. 65 (1939).

## The Cathode-Follower Stage—

Fig. 1 simply by substituting for the valve a generator of internal impedance equal to the valve impedance,  $R_a$ , and of EMF equal to the product of the valve amplification

Fig. 3.—Normal amplifier stage, shown for comparison with Fig. 1.



factor,  $\mu$ , and the alternating grid voltage,  $V_g$ . From the circuit of Fig. 2 we see that

$$\mu V_g = I_a (R_a + Z)$$

Also the grid voltage,  $V_g$ , is seen to be equal to  $(V_1 - Z I_a)$ , so that

$$\mu (V_1 - Z I_a) = I_a (R_a + Z)$$

which will be found to give

$$I_a = \frac{V_1}{R_a / \mu + Z (1 + 1/\mu)}$$

Now  $R_a / \mu$  is the reciprocal of the mutual conductance,  $g$ . Also  $(1 + 1/\mu)$  is very nearly equal to 1. Thus we may write

$$I_a = \frac{V_1}{1/g + Z}$$

This expression for the current through the load is the same as we should have for the current which would be sent through the load by an imaginary generator of internal impedance equal to  $1/g$ , and of EMF equal to  $V_1$ . In this hypothetical case the voltage  $V_1$  would be shared between the internal impedance and the load. Thus, *providing the load impedance,  $Z$ , is large compared to the internal impedance,  $1/g$* , almost the whole of the voltage  $V_1$  will appear across the load. The output voltage,  $V_2$ , will then equal  $V_1$ . The proviso stated in italics is easily satisfied, since with most valves the value of  $1/g$  is only a few hundred ohms.

We see therefore that the cathode-follower gives an output voltage equal to its input voltage (the cathode potential follows the grid potential—hence the name “cathode-follower”), and this output voltage

is not seriously affected by being connected to an impedance as low as a few thousand ohms—whereas the connection of a few thousand ohms directly across the load of an amplifier would very seriously reduce its output voltage.

Referring again to Fig. 1,  $I_1$  represents the alternating current produced in the grid circuit by the alternating voltage,  $V_1$ . The input impedance of the cathode-follower is  $V_1/I_1$ , and we require this to be high.

### Input Impedance

The path of  $I_1$  is through the valve and through  $Z$ . As in a normal amplifier stage, we can prevent the flow of electrons from cathode to grid (“grid-current”) by so biasing the grid that it never becomes positive with respect to the cathode. The requisite bias voltage is already provided for us in the cathode-follower stage by the voltage drop across  $Z$ ; in fact, the reader has probably already remarked upon the similarity between the cathode-follower circuit and the well-known automatic bias circuit. The grid-cathode capacitance, however, provides an alternative path through the valve. It is this capacitance together with the other interelectrode capacitances which causes the low input impedance of an amplifier stage. How is it then that the cathode-follower has not a low input impedance?

The explanation is apparent if we compare Fig. 1 with the amplifier circuit shown in Fig. 3. In Fig. 3 the grid-cathode capacitance is connected directly across  $V_1$ , so that the whole input voltage appears across this capacitance. In Fig. 1 the voltage across the grid-cathode capacitance is the resultant of  $V_1$  and the voltage across  $Z$ . Now the two voltages are nearly equal, and, moreover, they oppose each other (for if  $V_1$  be changed in such a way as to make the grid more nearly positive, the anode current will increase, and the extra voltage drop across  $Z$  will be in such a direction as to make the grid more negative). It follows that the resultant voltage across the grid-cathode capacitance will be very small. The current  $I_1$  will therefore be small, and the input impedance will be large.

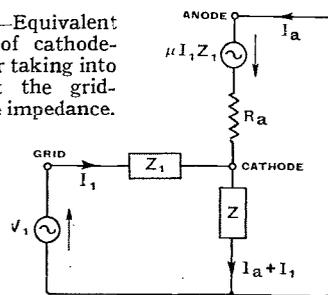
This neat piece of argument, however, cannot be regarded as a proof that the input impedance is in all cases large. We are not justified in assuming that the voltage across  $Z$  is nearly equal to the input voltage,  $V_1$ , since in deducing that these two voltages were nearly equal we did not take into account the grid-cathode capacitance. Fig. 4 shows the equivalent circuit of the cathode-follower, and differs from Fig. 2 only in the addition of  $Z_1$ , the impedance of the grid-cathode capacitance. Analysis of this circuit shows that the input impedance,  $V_1/I_1$ , is given by

$$Z(\text{input}) = V_1 / I_1 = Z_1 + Z \frac{R_a + \mu Z_1}{R_a + Z}$$

Now in a practical case the impedances  $Z$  and  $Z_1$  might be about equal (both being due to interelectrode capacitances) and of the same order as the valve impedance,  $R_a$ . Hence this result means that the input impedance is many times as great as the impedance of the grid-cathode capacitance alone. In short, the input impedance of the cathode-follower is great enough to permit of its connection across the load of a previous amplifier stage without unduly reducing the output voltage of that stage.

The fact that the cathode-follower has a low output impedance might have been deduced by observing that the circuit is similar to that of a negative feedback amplifier using current

Fig. 4.—Equivalent circuit of cathode-follower taking into account the grid-cathode impedance.



feedback and with a feedback ratio of 100 per cent. Such an amplifier would have a low output impedance and a voltage amplification ratio of 1:1. The cathode-follower also enjoys the other advantages of negative feedback, viz., freedom from distortion and comparative independence of variations in its operating voltages.

# Insulation Test Set

## Another Use for the Cathode-ray Tuning Indicator

By J. S. FORREST, M.A., B.Sc.

THIS note describes a simple insulation test set which is of great assistance to the radio or electrical engineer. The instrument operates from 230V. AC mains and is constructed from easily obtainable components. A test pressure of 400V. DC is used, and insulation resistances up to 100 megohms can be measured. This range has been chosen as being the most convenient for general use, but if necessary it is easy to vary the test pressure and resistance range over wide limits.

The main application of the instrument is the measurement of the insulation resistance of components and wiring. In the case of condensers it should be remembered that the insulation resistance is inversely proportional to the capacity so that very high insulation resistances should not be expected with condensers of several microfarads. In addition, domestic electric appliances, such as vacuum cleaners and irons, may be tested for leakage to the frame.

As can be seen from the circuit diagram (Fig. 1), the instrument consists of a cathode-ray tuning indicator (6U5) with mains power unit. The insulation resistance to be tested is connected across the terminals A B; the leakage current then flows through the variable resistance R<sub>1</sub>, thus altering the grid potential and consequently the shadow angle.

If the object under test has an insulation resistance  $r$ , and if  $E$  is the HT test voltage, then the leakage current flowing through the test object, neglecting the effect of R<sub>5</sub>, is  $\frac{E}{R+r}$ , R being the resistance of R<sub>1</sub>.

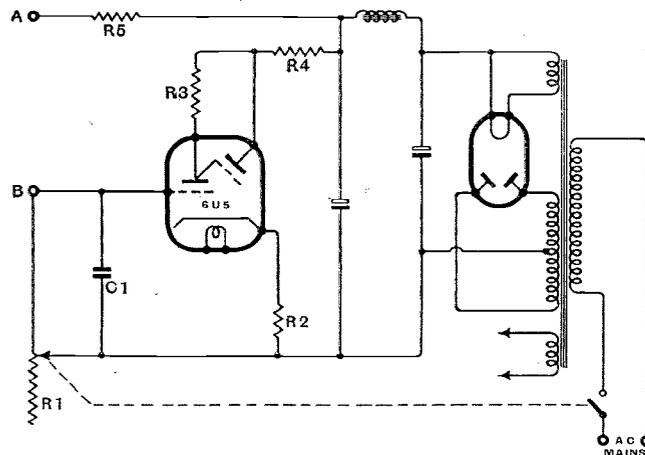
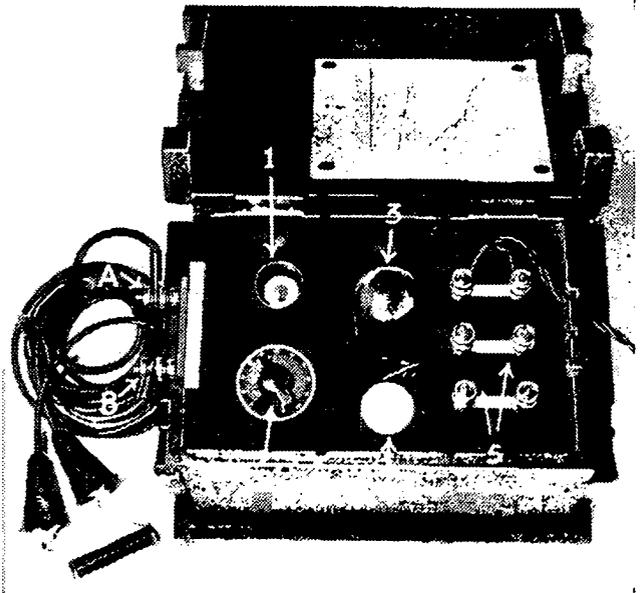


Fig. 1. Circuit diagram of the test set. To reduce risk of damage, the on-off switch and rheostat R<sub>1</sub> are ganged together in such a way that the latter is at zero value when first switching on.

The increase in grid potential due to the leakage current flowing through R<sub>1</sub> is therefore  $E_0 = \frac{ER}{R+r}$



The complete test set. Key: 1, cathode-ray indicator; 2, rheostat R<sub>1</sub>; 3, rectifier; 4, smoothing condenser; 5, HT and LT supplies.

$$\text{so that } r = \frac{R(E - E_0)}{E_0} \dots \dots \dots (1)$$

Thus for a given increase in shadow angle corresponding to an increase of grid potential  $E_0$ ,  $r$  is proportional to R, i.e., the setting of resistance R<sub>1</sub> is a direct measure of the insulation resistance under test. It was found best to adopt as a working value a change in grid potential of from -8V to -4V, corresponding to an increase in shadow angle of from 20° to 45°. The change in grid potential  $E_0$  is then 4V, and as the HT voltage is 400V, it is seen from equation (1) that  $r$  is approximately 100R.

The following features of the circuit are worthy of note:—

The most important component is the resistance R<sub>1</sub>. It should be of the exponential type and should have a consistent performance. A Centralab potentiometer having a value of 1 megohm was used by the writer; this enables insulation resistances up to 100 megohms to be measured, although the range can be proportionately increased by using a 5-megohm resistance. The mains switch is incorporated in the resistance in the usual way as this makes it less likely that high voltages will be applied to the grid due to the resistance being left in the maximum position.

In order to give a suitable shadow angle a 3,000-ohm cathode bias resistance R<sub>2</sub> is used, giving a bias of -8V. The resistance R<sub>3</sub>, in series with the anode of the

## Insulation Test Set—

tuning indicator, has a value of 1 megohm, and a 100,000-ohm resistance  $R_4$  is used to reduce the target voltage to 180V.

A 150,000-ohm 1-watt resistance  $R_5$  is connected in series with the test supply in order to avoid damaging the power unit if the insulation resistance of the test object is abnormally low.

A 0.1-microfarad condenser  $C_1$  is connected across the input to the indicator. This condenser should be of good quality, and its purpose is to eliminate induced AC voltages which may be picked up by the grid and which give rise to a poorly defined shadow angle.

The mains supply unit is conventional. The mains transformer should have a 350-0-350V high-tension winding and should be provided with low-tension windings to suit the valve heaters.

As shown in the accompanying photograph, the components are assembled in a strong box with a lid so that the instrument may withstand transport and rough handling. The resistance  $R_1$  is mounted on a bakelite panel and is provided with a knob (Bulgin K58) and dial (Bulgin IP8) in order that the setting may be read accurately. The tuning indicator is mounted beneath the panel, and the shadow angle is observed through a circular hole. A sheet of celluloid, marked with an angle of  $45^\circ$ , is fixed underneath the panel directly over the end of the indicator in order to facilitate the adjustment of the shadow angle to exactly  $45^\circ$ . The angle may be clearly marked on the celluloid by means of scratched lines filled in with black.

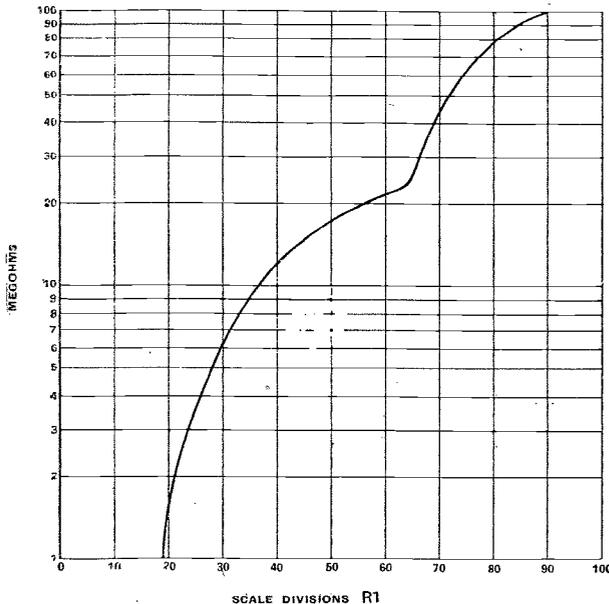


Fig. 2. Calibration curve of the author's instrument.

In order to increase the utility of the test set the HT and LT supplies from the power unit are brought out to terminals mounted on a second bakelite panel; this is very convenient when testing receivers in which the power unit is faulty.

The instrument is switched on with the resistance at the lowest value. With the terminals AB open-circuited

a shadow angle of about  $20^\circ$  should be obtained, corresponding to a grid potential of  $-8V$ . The insulation resistance to be tested is then connected across the terminals AB and the resistance  $R_1$  increased until a shadow angle of  $45^\circ$ , corresponding to a grid potential of about  $-4V$ , is obtained. The setting of the resistance is then noted and the insulation resistance obtained from the calibration curve. The calibration for the author's instrument is shown in Fig. 2. It will be noted that the "law" of the resistance used is only very approximately exponential; the resistance element is actually made up of two linear portions. The calibration will vary if different components are used, and it is best to carry out an individual calibration in each case. If the characteristic curve of the tuning indicator is available an approximate calibration may be obtained by measuring the value of the resistance  $R_1$  at various settings and by making use of equation (1). It is better, however, to connect high resistances of known value across the terminals A B and to determine the setting of  $R_1$  to give a shadow angle of  $45^\circ$ .

## Book Review

**Elementary Handbook for Wireless Operators.** By W. E. Crook, A.M.I.E.E. Pp. 102 + xii; 138 figures. Sir Isaac Pitman and Sons, Ltd., Parker Street, Kingsway, London, W.C.2. Price 4s. net.

AT a time when so many men are expecting to join the wireless branches of one or other of the Services, this book makes an opportune appearance. As the author says in his preface, the beginner in wireless cannot see where he is going; unlike those concerned with more mechanical arts, the radio student finds himself constantly being apparently side-tracked, and it is not until the latter stages of his course that the things he has learned begin to take shape as a connected whole. The present book aims at presenting a general view, enabling the student to tackle more comprehensive books and "to see where he is going" when immersed in the intricacies of a wireless course.

Some prior knowledge of elementary electricity and magnetism is generally assumed in books of this kind, but in the present case it is not essential to the reader, as there is a helpful chapter on Electrical Principles. This is preceded by another and shorter introductory chapter on Signalling, in which information on various non-technical aspects of wireless communication is given. Such subjects are usually ignored in a technical handbook, but their inclusion is well in keeping with the general principle of showing the student where his efforts are taking him.

The main body of the book explains the technique of wireless transmission and reception with commendable clarity and conciseness. In a small book of this nature there is inevitably some over-simplification in places, but where necessary the author warns the reader that he must be prepared for additional complexity as his studies advance. Accessory apparatus such as measuring instruments and power-supply equipment are explained, and there is a chapter on direction finding, in which the principles of bearing indication by cathode-ray tube are touched upon.

For the purpose for which it is intended, the book fulfils its object admirably, and so can be recommended for preliminary study to anyone who expects to join the Services or Merchant Navy as a wireless operator. Apart from the raw beginner, those who have previously been concerned only with broadcast reception will benefit from reading it.

H. F. S.

# Making the Most of Short Waves

## Improving the All-wave Receiver

By L. A. MOXON, B.Sc.,  
A.C.G.I.

(Concluded from page 151, June issue)

AS stated in the first instalment of this article, there are two main methods of band-spreading, with a possible third. The auxiliary capacity method, Fig. 5 (a), gives a very linear scale if used with a straight-line capacity condenser. It is generally more convenient to earth one side of the condenser as in 5 (b). This gives a slightly less linear scale and slightly less constant oscillator voltage, but these effects are of minor importance. Alternatively, a tuned grid or tuned anode oscillator circuit can be used. Fig. 5 (c) is for use when a standard gang condenser, e.g., the one used for medium- and long-wave tuning, is available for band-spreading. This gives the band-spread scale a calibration of the type shown in Fig. 6. This does not look ideal, but is actually quite useful. Since the frequency coverage is proportional to the frequency of the band in use, there is some tendency towards cramping the scale on the higher frequency bands. This can be avoided by using the flat portion of the tuning curve, AB, for these bands, and the portion CD for lower frequencies.

Fig. 7 shows another artifice to the same end. The effect of this is that

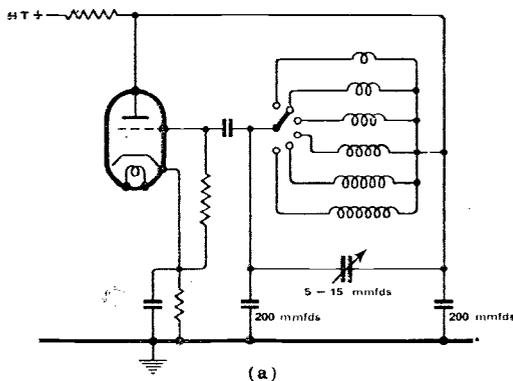


Fig. 5. Diagram (a) shows a Colpitts oscillator with band-spreading by coil switching and auxiliary capacity. The valve may be a separate triode oscillator or the corresponding section of an FC valve. Diagrams (b) and (c) show modifications as described in the text.

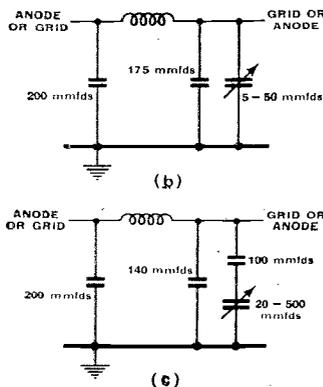
the lower the value of L, the smaller the proportion of the tuned circuit across which the variable capacity is connected. A value of about  $\frac{25}{30}$   $\mu$ H for the auxiliary inductance L<sub>1</sub> will double the spread of the 21-Mc/s

band, widen the 15-Mc/s band by 30 per cent., and have a negligible effect on 6 Mc/s. It may consist of a few inches of wire, or a small loop in the wiring, and, being awkward to measure, can be adjusted by trial.

The variable inductance method, Fig. 8, gives a frequency cover inversely proportional to frequency. The inductance L<sub>1</sub> may be designed to cover 6 to 7.3 Mc/s with no other inductance in circuit. These extra inductances can be switched in as required for the higher frequencies. The most practical method of varying the inductance would appear to be an iron dust core. Metal spades are unsatisfactory as sufficient variation of inductance would involve severe damping of the oscillator coil.

This method appears very promising, but calls for some ingenuity as there are no suitable variable inductances on the market. Double frequency changing offers a third possibility, as stated last month.

It is quite possible to switch



condensers as well as coils, and thus arrange to spread each band over the entire scale, or as required. This may be somewhat elaborate, but is quite straightforward and calls for no special comment.

The RF signal circuits may be preset to the middle of each band, either using a fixed inductance and switching capacities across it, or preferably by the reverse process. This involves some loss of gain and image suppression at the band edges, and if possible these circuits should be spread in the same way as the oscillator, but using different capacity

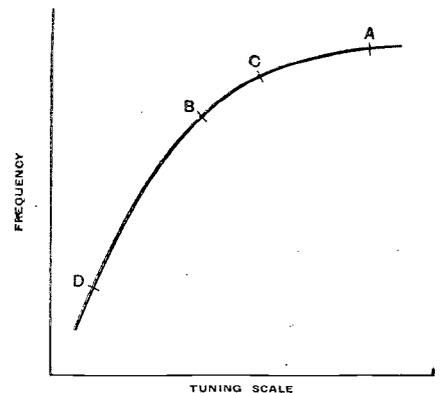


Fig. 6. Scale calibration obtained with the arrangement of Fig. 5(c).

values as required by gain considerations. The only systems that lend themselves readily to this are those of Figs. 5, 7 and 8, and more especially that of 5 (c). If a two-gang condenser is available, one section should be used for the oscillator and one for the RF anode circuit. It is rather a waste of effort to spread the aerial circuit, since this is considerably flattened by the aerial, and in addition the aerial introduces a very variable element into the ganging. It is essential to band-spread the image suppression circuit described earlier.

Colpitts oscillator circuits are recommended, partly for stability but chiefly for convenience in coil construction, as they require no tapped coils or coupling windings. Other circuits are sometimes more useful in particular cases, but the same principles apply.

One of the main obstacles to reliability on short waves has been the difficulty of designing stable circuits for the local oscillator. Unless these are reasonably constant it is obviously rash to indicate on the scale where any particular station may be found, and

the listener must be left to grope for it. "Reasonable" means within 5 kilocycles (with 10-kc/s channels), and this at 15 megacycles means one part in 3,000. On medium waves only a tenth of this accuracy is needed for the same result, and was regarded as good going, until quite recently. The principal causes of day-to-day variations in calibration are the effect of humidity on coils and condensers, the effect of temperature on the latter, and random changes in trimmers and gang condensers due to mechanical imperfections. In addition, oscillator frequency may be affected by the AVC voltage on the frequency changer, and in the case of mains sets there are as a rule large cyclic changes due to the warming-up of valves and other components. In addition to disturbing the calibration the latter makes it necessary to keep readjusting the receiver during the first half-hour or more after switching on. The AVC effect is not usually serious with modern frequency changer valves, but can produce quite a passable imitation of selective fading.

The greater part of the warming-up drift is usually caused by changing inter-electrode capacity of the oscillator valve due to the considerable heat given off by the heater. It takes place relatively quickly, and after about 20 minutes there is no further change. Other offenders are the trimmers, the self-capacity of the coil, and the gang condenser, in that order. It is an obvious precaution to see that none of these is subjected to excessive heat.

The effect of humidity can be avoided, in the case of coils and fixed condensers, by suitable impregnation. The other effects are all concerned with the residual capacities, except for very minor shortcomings on the part of the gang condenser. When the SW

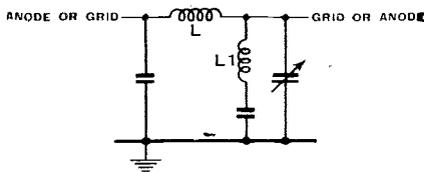


Fig. 7. Showing the use of an auxiliary inductance L1 to increase the spread of high-frequency bands.

bands are selected by variable condenser these residual capacities or strays increase their percentage of the total capacity, and hence the percentage drift, as the square of the frequency. The drift in kilocycles, therefore, increases as the cube of the frequency. Warming-up drift has

rarely been found less than 25 kc/s from one minute to one hour after switching on. About 15 kc/s is due to the valve and unavoidable. The drift normally occurs as an increase of capacity with temperature, but ceramic fixed capacities are now available with negative temperature coefficients. One of these can be used with a suitable heater to produce a compensating drift in the opposite direction. This has the disadvantage of increasing the strays and reducing the tuning range, and is also rather imperfect due to the differences in heating and cooling rates of the various associated components.

Much greater stability is possible with switched inductance systems. The strays can be swamped by large fixed capacities, and the valve drift reduced to some 3 kc/s at 15 megacycles. Very stable condensers of silver-on-mica construction are available for this purpose. Any remaining drift can be measured, and compensated by using a negative coefficient condenser for part of the swamping capacity.

## Double Superheterodynes

Double frequency changing (DFC) is not new. For many years adaptors have been in the market for converting SW signals into medium- or long-wave signals for reception on sets without any SW band. As a rule, these devices do not possess any special virtues beyond simplifying the addition of SW to an existing set. Allied with an RF stage and preselector circuits, however, DFC can be made a thorough cure for images, and free from double-beat interference. This is because a high value of IF can be chosen for the first frequency changing process, and later changed to a low value for amplification and selectivity. The normal difficulty on short waves is that a low value of IF is needed for obtaining adequate gain and selectivity, and this results in too small a separation of signal and image for easy rejection of the latter; similarly, with double beats, DFC is of further interest as affording a possible means of converting almost any superhet to the highest possible standard of SW performance by external addition of the requisite RF and FC circuits. It has, however, its special problems which must be understood if it is to be used successfully.

There are two troubles likely to be encountered with DFC. The first is additional images, which arise as follows: Let  $f_1$  be the first intermediate frequency and  $f_2$  the second. The

second oscillator frequency will then be  $f_1 \pm f_2$ , and a signal of  $f_1 \pm 2f_2$  reaching the second FC would cause second channel interference. If  $f_w$  is the frequency of a wanted station, the first oscillator will have a frequency  $f_w \pm f_1$ . Taking the plus signs, the image frequency will be  $f_w + 2f_1$ . In addition,

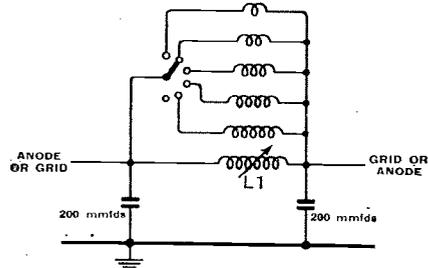


Fig. 8. Band-spreading by variable inductance.

signals at  $f_w - 2f_2$  or  $f_w + 2f_1 + 2f_2$  will beat with the first oscillator to give, amongst other things, components of  $f_1 + 2f_2$ . These must not be allowed to reach the second frequency changer, and fortunately they can be easily prevented from doing so by circuits selective to  $f_1$ . Otherwise there will be, in all, three images.

Harmonics of the second oscillator are a worse problem. Some voltage of each harmonic is almost certain to get on to the grid of the first frequency changer. It will most likely do so without passing through the preselector circuits and will therefore be received at two points on the dial. There appear to be two ways of tackling this problem. One is to use the lowest value of IF consistent with good image rejection; the harmonics, being of a high order, will then be relatively weak, provided every precaution is taken to avoid stray capacities and common impedances between the circuits of the two frequency changers. It will be an advantage to tune the second oscillator to the low rather than the high side of the first IF. If these circuits are used for band spreading, this helps matters, since the  $n$ th harmonic is then  $n$  times more sharply tuned than the signal and the harmonic whistles, if any, can be avoided by a slight tuning-shift. It is also of advantage to use as much gain as possible in front of the first FC, since weak signals at this point will be most liable to trouble.

An alternative is to use the highest value of first IF, consistent with ease in rejecting  $f_1 + 2f_2$ . Harmonics will then be relatively few, and care in choosing the exact frequency will place them and their images outside the broadcast bands. This was done on

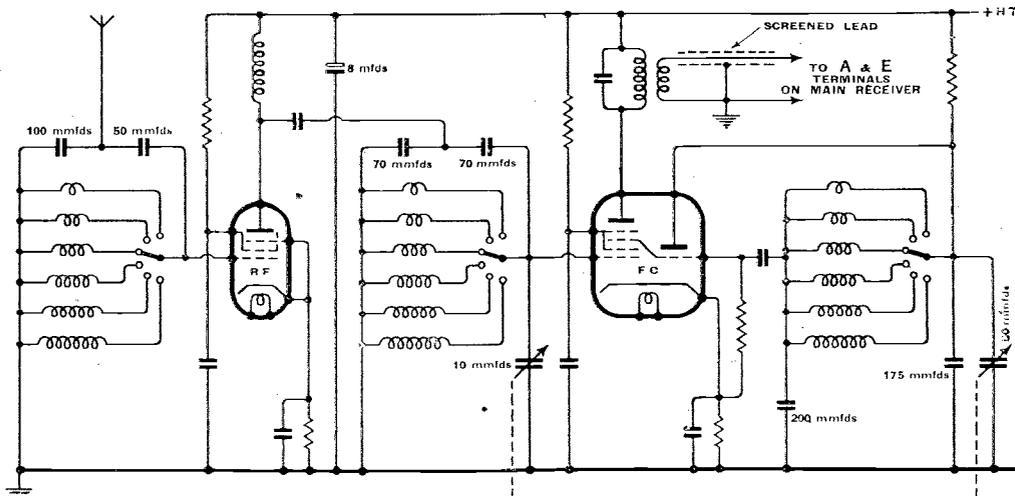
**Making the Most of Short Waves—** the Murphy A52, where a second oscillator frequency of 2.635 megacycles, giving an IF of 3.1 megacycles, was found satisfactory.

## Interference at IF

One other trouble which may be encountered is interference from stations operating on the first IF and picked up on these circuits. If reasonable care is taken to screen them and to prevent them sharing any common impedance with the aerial circuit, the trouble is avoided except in the immediate neighbourhood of a powerful station operating on the IF or the image of the IF. The remedy then lies in choice of a different IF.

Fig. 9 is a recommended arrangement for a converter. Various alternative band-spreading arrangements have been already discussed. A very convenient arrangement, but one involving slight

Fig. 9. Circuit of a short-wave converter with band switching. The capacity values marked are intended as a rough guide. RF and FC valves may be Mazda SP41 and TH41 or equivalents.



loss of performance at the band edges, might be to use fixed tuning in the converter and vary the tuning of the main receiver by about plus or minus 100 kc/s for band coverage. Screwed iron cores provide the best means of adjusting inductances. No AVC has been applied to the converter, as it is assumed that the main receiver used will possess an adequate measure of control; the disadvantages of over-perfect AVC and AVC on RF stages will be discussed later. Fig. 9 is intended only as a guide, and indicates few details. The experimenter will prefer to evolve these for himself, in accordance with circumstances and general principles.

Fading takes two forms. The carrier and sidebands may fade together, or some of these components may fade more than others. In the latter case (selective fading) distortion results, and is often very severe, especially on SW. Automatic volume control enables the carrier at the detector to be kept reasonably constant, except during a very severe fade, by increasing the sensitivity of the receiver as the carrier fades. Although a cure

for ordinary fading, this is liable to make selective fading more unpleasant. Distortion is worst when the carrier fades, leaving the sidebands behind; if the carrier is restored to full strength by increased sensitivity, the detector will receive a strong, heavily over-modulated and distorted signal. The result is a large increase in volume synchronising with the distortion. The value of very efficient AVC is therefore controversial, especially on SW, and the use of undelayed AVC is felt to be no disadvantage. In the case also of extreme non-selective fading, it is pleasanter to allow the signal to fade somewhat before disappearing into the noise, than to be greeted by

In adjusting the grid circuit of a SW frequency changer, it is very easy to be misled by false "peaks." The result of this is bad image suppression and poor frequency stability, which may not be detected by a casual test. The explanation of this effect is as follows: There is a tendency for the signal circuit to couple with the oscillator through valve and wiring capacities. This is not serious with correct frequency separation, but if tuned too close to it the signal circuit pushes the oscillator frequency away from its own frequency and can produce the correct intermediate frequency although wrongly trimmed. Sometimes this gives greater gain than the correct

loud bursts of noise almost without warning. For the same reason, the value of very high sensitivity is doubtful. Sensitivity should, however, be adequate to ensure reasonable volume from any station stronger than the irreducible minimum of background noise.

## Desirable AF Characteristics

The response of the audio-frequency circuits for SW reception is worth some attention. On short waves, speech is likely to be of more interest than music, and requires either an adequate bass and top response, or restriction of both, for greatest intelligibility. The high noise levels and fading prevalent on SW call for restriction of top response. A tone control is usually fitted for this purpose, but it tends to be useful to reduce bass response as well. A control for this purpose is an added complication, and in an "all-wave" receiver a useful compromise may be effected by using a smaller value of AF or output valve grid coupling condenser on SW, to reduce bass by about 4-6 db. at 50 cycles.

adjustment, but it must be avoided. It is best to start trimming with the signal circuit tuned on the correct side of the oscillator, and with considerably more than the correct frequency separation. The first peak encountered will then be the right one.

False trimming points may be caused in another way. It is often possible to continue the adjustment of trimmers or iron cores beyond their maximum value. They then decrease in value and give the effect of a peak even though the coil requires more turns or the trimmer is not large enough. If these dangers are understood they are easy to avoid.

It is doubtful whether the entertainment possibilities of SW are fully realised by the ordinary listener, and the hope may be expressed that a large percentage of future all-wave receivers will embody easily operated tuning systems, efficient RF stages and image rejectors or double frequency changing, and stable oscillator circuits.

The author is indebted to Murphy Radio, Ltd., for permission to publish the results of work carried out in their laboratory.

# Servicing Equipment and Its Uses

## Part I.—Multi-range Meters, or Analyzers

The first of a short series of articles for newcomers to the art of broadcast receiver maintenance who are carrying on the work of regular service men now in the Forces

By "SERVICE"

IT is the purpose of this short series of articles to describe the chief items of equipment with which full acquaintance must be gained for efficient and economical servicing; in addition, advice will also be given on the use of the equipment and how it may be employed to the best advantage.

Every service workshop should have the following pieces of service equipment, in addition to its usual collection of small tools and spare parts:—

(1) A sensitive analyzer, or combination meter, which will enable readings to be taken of volts, milliamps and resistance values.

(2) A service oscillator for aligning the RF and IF circuits of a receiver.

These two items form the fundamental basis of all service and maintenance work, and although, as will be described later in this series, other equipment can be of great assistance, efficient servicing cannot be carried out without them. The most used instrument in the service workshop is the analyzer.

A service analyzer is not a piece of mysterious apparatus which will, by pressing a button, tell you exactly what is wrong with a faulty receiver and rectify it for you. It is not a fault repairer; it is not even a fault finder if the user cannot interpret the meter readings. The chief advantage of an analyzer is that it presents in a compact form a means of analyzing the circuits of a receiver in order to find out whether the voltages, currents and resistances differ from the values to be expected or which are given in manufacturers' service manuals.

Practice in the uses of an analyzer will soon bring about the required confidence, which will be gained all the sooner if one realises that the most intricate of analyzers is but a meter which applies Ohm's law to the problem under consideration.

When the analyzer is adjusted for measuring volts a resistance of a known value is put in series with the meter circuit. The designer knows that when a certain voltage is applied to the meter in this manner, the current which will flow through the meter circuit at that voltage will move the meter needle a certain distance along the scale. The latter is, therefore, marked at this point with that voltage, and other calibration points calculated and marked on the scale according to requirements.

For measuring resistances an internal battery of a known voltage is brought into the internal analyzer circuit, and this voltage will drive current through the meter circuit, the value of the current being determined by the unknown resistance. A very small current flowing will mean a high value resistance, while when a large current flows a low resistance will be indicated, and the designer of the meter can mark the scale of the instrument at various points where the current would move the meter needle when a certain resistance is in series with the meter and the small dry battery.

### Measuring Current

For current readings the analyzer circuit is a little more complicated, because modern meters take very little current, and to measure large currents a diversion, or shunt as it is technically termed, is designed to be connected in parallel with the meter movement itself to take a definite proportion of the total current flowing in the circuit.

An essential thing to remember when using a multi-range meter or analyzer is to connect it across the circuit to measure the voltage or resistance of the circuit and in series with the circuit to measure the current flowing through that circuit.

The panel of a typical high quality analyzer is shown in the accompanying photograph, from which it will be noticed that test leads may be put into various pairs of sockets for volts, ohms, current, etc., while a switch is provided to select the range of the measurements to be obtained from the various pairs of sockets with certain exceptions which need not concern us here.

### Understanding the Meter

It is good practice to use the analyzer for just one of its applications at a time by starting with the voltage range and measuring the voltages of HT batteries with their various tapings and accumulators. The voltages to be measured will be known approximately and, therefore, can be used as a check against the readings obtained.

When voltage measurements are thoroughly understood, then resistance tests may be made, using components of known resistance and comparing these values with those obtained from the analyzer. Finally, the current ranges may be experimented with, and for this purpose a battery receiver is very useful, as it is a simple matter to connect the analyzer in series with the HT battery sockets and the various battery leads.

Whenever you have finished using an analyzer always leave the instrument set for the measurement of a high voltage. By doing this you will, in the majority of cases, prevent damage to the instrument should you connect it to a circuit giving a high voltage before you have set the controls to their correct position to cover that voltage.

When applying the analyzer to a circuit and it is not known just what values of voltage and current are to be met with, always start with the highest ranges, and then if only a flicker of the needle is apparent the instrument may be adjusted to the next lower range, and so on until an easily observed reading is obtained.

As a matter of interest, many meters

**Servicing Equipment and Its Uses**— give their most accurate readings when the needle is midway or towards the maximum end of any particular range, and if a range is chosen where this occurs, then more accurate and easily observed readings can be made.

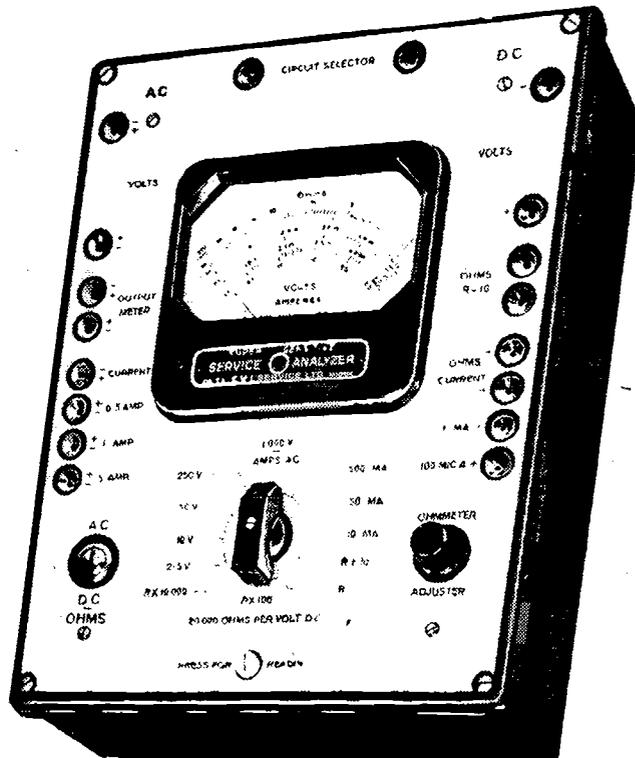
As normally employed, an analyzer is primarily designed to enable the circuit analysis of receivers to be undertaken, and this is accomplished by methodical application of the instrument to the components and test points in the faulty receiver. For example, using only the voltage ranges, the whole HT supply circuit of a receiver may be checked from the filament of the rectifier valve, which is the source of HT in AC receivers, right through to the anode and screen of the first valve.

Using the highest range available, which in most analyzers will be 0-500 volts, the HT voltage at the rectifier is measured.

This may be effected in the majority of cases by connecting the

*Courtesy E.M.I. Service.*

Arrangement of sockets and selector switch in a highly sensitive service analyzer.



Assuming, however, that we are examining a straightforward AC chassis with the negative lead of the analyzer clipped to the chassis, touching the positive test lead on to the heater socket of the rectifier valve holder should provide a reading of the full HT voltage.

## Voltage Analysis

The positive lead is then touched on to one side of the smoothing choke where the reading should be the same; and then to the other end of the choke. This connection should give a

field winding and thus to the centre-tap of the transformer secondary.

The voltages on the anode sockets of the various valve holders may be checked, still keeping the negative lead clipped to the chassis, but in these cases it is also desirable to check the HT voltage existing between the anode socket and the cathode socket on the valve holders by shifting the negative lead to the cathode socket. This is because an HT voltage will be shown between chassis and anode of a valve even when any cathode bias resistance in the valve circuit is open-circuited.

If desired, of course, the bias voltage may also be checked by keeping the negative lead of the analyzer clipped to the chassis and then switching the analyzer to a much lower voltage range, say, 0-10, and then applying the positive lead to all the cathode sockets of the valve holders to check the cathode bias. Output valves may have a higher bias voltage and the analyzer must be set to a suitable range.

Should any of the tests made for voltage readings on the anode sockets of the valve holders give no indication on the analyzer, then that circuit must be traced back component by component until a reading is obtained.

## Drawbacks of Current Tests

For instance, let us suppose that no volts are obtained on the anode of an IF valve; the positive test lead of the analyzer should be connected to the anode end of the IF transformer primary. If no reading is obtained at this point, a test connection may be made to the other end of the IF transformer primary. If a voltage reading is then obtained the transformer winding is proved to be faulty, or there is a badly soldered joint on it.

Voltage analysis on these lines is very useful in modern receivers where it is very difficult, and in some cases impossible, to insert a valve adaptor between the valve and its valve holder for measuring the anode current which used to be the first line of attack when things went wrong in earlier types of receivers. Also in cases where the fault is one which gives weak results, any attempt to measure the anode current by means of valve adaptors will frequently throw the receiver into violent oscillation which will upset all normal current readings and so mask the fault.

Taking voltage readings, especially with a high-resistance meter, has very little effect in this direction, and instead of looking for low anode currents

negative test lead to the chassis and the positive lead to one of the heater sockets of the rectifier valve holder. The exception to this procedure is where the chassis is isolated from the circuit by a condenser, as is generally the case with DC and AC/DC receivers. With this type of set the negative test lead must be connected to the negative point of the HT supply circuit. A study of the circuit diagram of the receiver, together with the information given in the voltage tables shown in the manufacturers' service manuals, will indicate where to connect to make the tests.

A warning must be given here with regard to AC/DC receivers, in some of which the chassis is "live" at the full mains voltage above earth.

slightly lower reading because of the voltage dropped across the choke, but if no reading is obtained this will indicate a faulty choke or faulty connection to it. In most modern receivers, of course, the field winding of the loudspeaker is used as a smoothing choke.

In some receivers the smoothing choke or the field of the loudspeaker is in the negative HT supply lead, and in these cases the centre-tap of the mains transformer HT secondary winding will be the ultimate negative point and the chassis will be positive in relation to it. To check the choke and the supply circuit in a receiver having this arrangement the positive test lead must be clipped to the chassis and the negative lead connected in turn to the ends of the choke or the loudspeaker

**Servicing Equipment and Its Uses—** high anode voltages will be the symptom which should cause suspicion to be directed to a particular circuit.

## Resistance Analysis

Another method of locating faults in a receiver, especially where it is not desired to investigate the circuits when they are "live," is by means of resistance analysis. If the analyzer is set to measure resistance and one of its test leads connected to the cathode of the rectifier valve, then the other lead may be progressively connected along the HT circuit to all the various anodes of the valves. The resistance reading should become higher and higher as the test is proceeded with. An indication of a fault may be obtained by this method in the following manner.

If a reading of, say, 1,000 ohms is obtained at one side of an output transformer, and also a reading of 1,000 ohms is obtained when the analyzer lead is connected to the other end of the transformer winding, then this proves that the transformer is short-circuited.

On the other hand, if a reading of 1,000 ohms is obtained on the first test and no reading at all obtained on the second test, then this indicates an open-circuited transformer winding, or bad connection to it.

the receiver being serviced is the sensitivity of the meter being used and the sensitivity of the meter with which the service manual data was compiled. If the two are of different sensitivity, the readings will not agree, but this may not necessarily mean that a fault is indicated. A high-sensitivity meter will give a higher voltage reading than will a low-sensitivity meter when connected across a valve or similar circuit for the following reason.

All the more commonly used measuring meters require current to operate them and this current is taken from the circuit which is being tested. Therefore, directly the test leads are connected to the receiver circuit a change is effected in that circuit which has to supply current to a resistance network—the analyzer components—for which the receiver was not designed. The voltage indicated by the meter is always rather less than that which actually exists under normal operating conditions.

## Meter Resistance

Now, this characteristic of measuring instruments would introduce no difficulty if it were not for the fact that different meters have different effects upon a circuit to which they are connected. Many readers will appreciate that, when a voltage is applied to a resistance, cur-

rent, and very misleading readings will be obtained when using it on a circuit in which high resistance values are present.

A more expensive meter, however, will have a very delicate meter movement attached to an exceptionally light needle, the whole assembly requiring only, in some cases, a fraction of a milliamp to move it from one end of the scale to the other, or what is termed technically, for full scale deflection.

## A Useful Tip

The sensitivity of meters is stated in terms of "ohms per volt" and a good-class meter will have a sensitivity of 1,000 ohms per volt, which means that when on, for example, a 100-V range the resistance of the meter is 100,000 ohms and only one milliamp is being taken from the circuit under test.

Many modern analyzers have an exceptionally high sensitivity figure in terms of ohms per volt. The effect of meters having varying sensitivities is shown in Fig. 1.

If a great deal of unnecessary work is to be avoided in looking for faults which do not exist, there must be a thorough understanding of what is meant by the voltages given in manufacturers' service manuals. Unfortunately, the sensitivity of service test

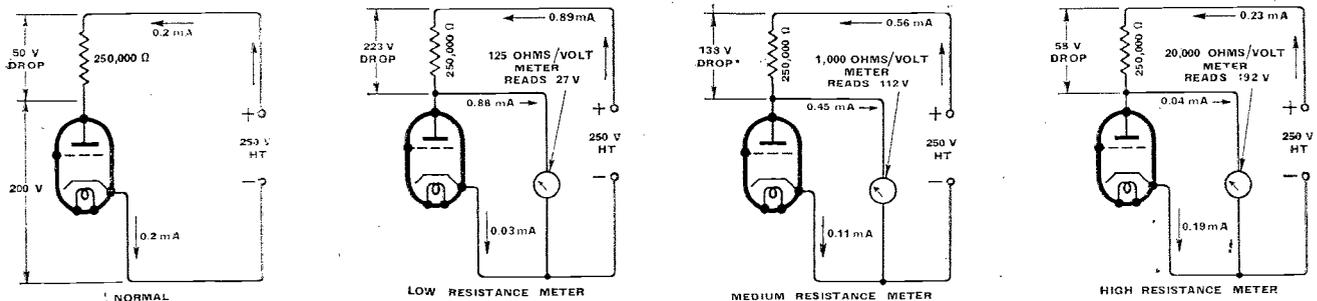


Fig. 1. Effect of meter sensitivity on anode current and indicated anode voltage.

Resistance measurements must be taken with great care when checking the primary winding of a mains transformer and the secondary winding of output transformers, as in these instances very low readings, of perhaps only 0.1 of an ohm, may be obtained even on a perfectly good component. Before taking such measurements the meter needle should be very carefully set to zero.

A very important consideration that must be kept in mind when comparing the voltages obtained on test with those given in the service manuals of

equipment is not standardised by the various manufacturers. Many of them often state in their manuals the sensitivity of the meter used, but where this is not stated it is well worth while finding out, and inserting the appropriate figures in the service manual for future reference. The results obtained when taking voltage tests will, even if they differ from the service manual, bear a definite relation to the data in the manual, depending upon the difference in sensitivity between the two meters. Knowledge of this will prevent false conclusions being drawn.

rent flows through the resistance. With the voltage remaining constant the higher the resistance the smaller will be the current flowing through it. This is the principal reason for the different effects that meters have upon the circuits being tested.

A very cheap instrument will have a very coarse meter movement with a decided amount of friction, and consequently a comparatively large current is required to move the meter needle from one end of the scale to the other. The resistance of the meter will be low in order to obtain the necessary cur-

equipment is not standardised by the various manufacturers. Many of them often state in their manuals the sensitivity of the meter used, but where this is not stated it is well worth while finding out, and inserting the appropriate figures in the service manual for future reference. The results obtained when taking voltage tests will, even if they differ from the service manual, bear a definite relation to the data in the manual, depending upon the difference in sensitivity between the two meters. Knowledge of this will prevent false conclusions being drawn.

# THE WORLD OF WIRELESS

## TRAINING OPERATORS

### Opportunity for Youths

AN appeal for young men who are still below the calling-up age was recently broadcast by Lt.-Col. C. V. L. Lycett, chairman of the Wireless Telegraphy Board. The scheme outlined by Col. Lycett concerns those who are over 16½ years old but had not reached the age of 18 on January 20th, 1941, and is for the training of wireless operators for the three Fighting Services and the Merchant Navy. In order to meet the ever-increasing demand for wireless operators the civilian wireless schools to co-operate with the Services in training volunteers.

The Fighting Services guarantee to enlist volunteers as wireless operators, provided, of course, they are physically fit and otherwise suitable, on obtaining the P.M.G.'s Special Certificate.

The examination for the certificate includes: Morse, sending and receiving at 20 w.p.m.; practical working knowledge of wireless apparatus; and a knowledge of the regulations contained in the P.M.G.'s Handbook.

Tuition fees and ordinary travelling expenses to and from school will be refunded to a maximum of £25.

Names and addresses of schools at which trainees should enrol can be obtained from the Inspector of Wireless Telegraphy, Telecommunications Department, General Post Office, London, E.C.1.



Col. A. S. Angwin, D.S.O., M.C., B.Sc. (Eng.), Post Office Engineer-in-Chief, who was created a Knight Bachelor in the Birthday Honours conferred by the King. He assumed his present office in June, 1939. Col. Angwin contributed largely to the design of the Post Office transmitting stations and is a member of the Television Advisory Committee.

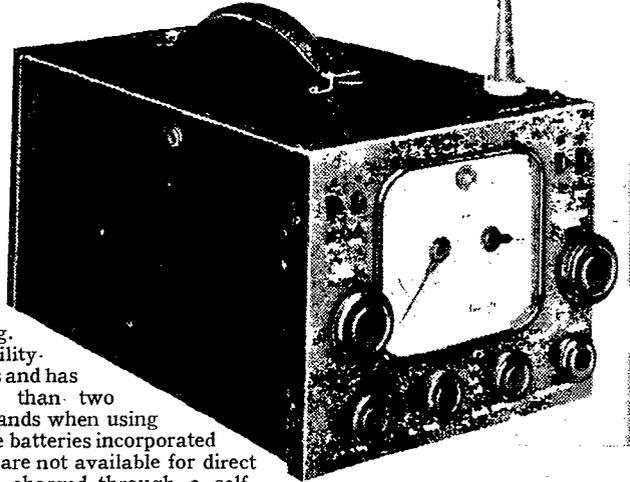
## FM IN U.S. ARMY

### Release of Patent Rights

IT was recently announced by Mr. Henry Stimson, the American Secretary of War, that Major E. H. Armstrong, the inventor of the system

The latest design of communications receiver produced by the Hallicrafters Company of Chicago is the portable Sky-Traveller (Model S-29). Designed to communications receiver tolerances, it has a frequency coverage from 542 kc/s to 30.5 Mc/s in four steps and includes electrical band-spreading.

It incorporates permeability-tuned RF and IF circuits and has a sensitivity of better than two microvolts on all four bands when using the telescopic aerial. The batteries incorporated for use where AC or DC are not available for direct mains operation can be charged through a self-contained charger. The weight of the Sky-Traveller, which costs \$59.50, is 18 lbs.



## PORTABLE MAINS OR BATTERY COMMUNICATIONS RECEIVER

of transmission known as frequency modulation, has granted the U.S. Army full rights to the use of his FM patents of national defence.

In accepting the offer, which covers 17 basic patents and is good "for so long as the present national and international emergency exists," Mr. Stimson thanked Major Armstrong for "the patriotic example afforded by such a distinguished inventor."

It is understood the U.S. Army is developing three new receivers for armoured units which will incorporate FM. It will be remembered that it was suggested in *Electronics* that the Germans used FM during their lightning advances in the Low Countries.

## GMT FROM DELHI

THE Greenwich time signal is now being broadcast from all four Delhi transmitters of All India Radio. The B.B.C.'s transmission of the signal is received at the Delhi receiving centre and then rebroadcast. An interesting feature of the rebroadcast is that in order to cut out the B.B.C. programme when the time signal is superimposed thereon, as is sometimes the case, a filter has been incorporated in the receiving equipment which eliminates all but the frequency of the "pips."

## WAR DAMAGE

### Compensation for Loss of Apparatus

IT appears that a certain amount of confusion exists in the minds of some readers regarding compensation for loss through enemy action of such articles as wireless apparatus and sound-recording equipment. Such apparatus represents considerable monetary value, and the question has naturally been asked, "Are these things classed as luxuries?"

Under the War Damage Act, 1941, no one article (motor cars, motor cycles and ships excluded) can be covered for more than £50 or 5 per cent. of the total sum insured, whichever is the greater. The value at which the article is assessed is the replacement cost at current prices, less an amount for depreciation. This applies to expensive radiograms. Therefore, one cannot get more than £50 for any single article unless one has insured for more than £1,000.

Although various amounts of free compensation for "householders," etc., are provided under the War Damage, Private Chattels Scheme, owners of expensive radio and recording apparatus may find that the free insurance is not sufficient to cover them as well as their other personal effects. In

this case further insurance can be obtained at the rate of £1 per cent. up to £2,000. An explanatory memorandum and application forms can be supplied by fire insurance companies and Lloyd's.

It is wise to prepare a list of apparatus owned, which, together with invoices and receipts, etc., showing the value of the apparatus, should be kept in a place of safety elsewhere ready for use as evidence in assessing a claim.

### THE IONOSPHERE AND METEOROLOGICAL CONDITIONS

IN the recent annual report of the work of the Australian Radio Research Board reference is made to the experiments conducted at Sydney concerning the interdependence of the condition of the F<sub>2</sub> region of the ionosphere and the meteorological conditions on the ground. The work has included the correlation of both these phenomena with terrestrial magnetic disturbances, and a definite connection between them has been found. A paper entitled "Magnetic Disturbances and Region F<sub>2</sub> of the Ionosphere," embodying the results of the investigation, is being published.

### AERIAL "ELIMINATORS"

#### Exaggerated Claims Vetoed

THE Federal Trade Commission of the U.S.A., which was recently given greater legal powers, is on the warpath against the making of exaggerated claims for so-called "antenna eliminators." According to the F.T.C. ruling, makers must no longer represent, say, a four-inch device as equivalent to a 75-foot aerial, or guarantee their devices to render outdoor aeriels unnecessary. It must not be claimed that they produce better tone, greater volume, sharper selectivity, or that they help to reduce interference.

#### CANADIAN NEWS

A NEW record for sales of receivers was set up in Canada last year, the increase over 1939 being 18 per cent. The production of receivers in the Dominion increased by over 40 per cent., whilst the production of valves rose by 63 per cent. In both cases the imports were considerably reduced. Of the 385,000 receivers sold, 57 per cent. covered the broadcast band only, whilst the remainder covered both the medium- and short-wave bands. The number of receiving licences in

Canada is now well over 1,500,000.

Commenting on the many complaints from Montreal which have arisen out of the changes made in the frequency allocations in accordance with the North American Agreement, Mr. G. E. Sarault, chief engineer of the Canadian Broadcasting Corporation, said that because the rearrangements have been made on a national, rather than an international, basis many of the well-known United States stations are now unreceivable. It was pointed out that the basis of the allocation of wavelengths is that where one country is assigned a channel for a Class 1 station, such as CBF, the Montreal station in question, none of the other signatory countries is permitted to use that frequency if by so doing they might interfere with the reception of the Class 1 station in its own country.

The president of the Canadian Marconi Company recently stated that the company is now no longer dependent upon the United States for all the quartz crystals used to maintain the constancy of radio frequencies in transmitters and receivers. This has been made possible by the help given by one of the most important

## NEWS IN ENGLISH FROM ABROAD

### REGULAR SHORT-WAVE TRANSMISSIONS

Country : Station	Mc/s	Metres	Daily Bulletins (BST)	Country : Station	Mc/s	Metres	Daily Bulletins (BST)
<b>America</b>				<b>Manchukuo</b>			
WNBI (Bound Brook)	17.780	16.87	4.0†, 6.0.	MTCY (Hsinking) ..	11.775	25.48	9.0 a.m., 11.5.
WCBX (Wayne) ..	9.650	31.09	8.30†, 10.0†, 11.45†.	<b>Sweden</b>			
WCBX ..	11.830	25.36	7.30†.	SBO (Motala) ..	6.065	49.46	11.20.
WCBX ..	17.830	16.83	2.0, 3.0, 4.15†, 5.0†, 5.30†.	<b>Thailand</b>			
WGEO (Schenectady) ..	9.530	31.48	8.30†, 10.55§†.	HSP5 (Bangkok) ..	11.715	25.61	1.45.
WGEA (Schenectady) ..	15.330	19.57	1.0, 2.0†, 6.0, 7.45.	HSPJ ..	19.020	15.77	1.45.
WRUL (Boston) ..	11.790	25.45	8.15§†, 9.30†.	<b>Turkey</b>			
WRUL ..	15.350	19.55	8.15§†, 9.30§†.	TAP (Ankara) ..	9.465	31.70	8.15.
<b>Egypt</b>				TAQ ..	15.195	19.74	1.15.
SUX (Cairo) ..	7.860	38.14	7.50, 11.10.	<b>U.S.S.R. (Moscow)</b>			
<b>Finland</b>				49-metre band ..	—	—	8.30, 10.0, 12.0 midt.
OFP (Helsinki) ..	8.585	34.94	9.20.	41 ..	—	—	8.30, 10.0.
OFN ..	11.980	25.04	9.20.	31 ..	—	—	6.45, 8.30, 10.0.
<b>French Equatorial Africa</b>				25 ..	—	—	2.30, 6.45, 8.30.
Brazzaville ..	11.970	25.06	9.45.	19 ..	—	—	} 8.33 a.m., 2.30.
<b>India</b>				16 ..	—	—	
VUD2/3 (Delhi) ..	9.590	31.28	10.0 a.m., 2.30, 5.50.	<b>Vatican City</b>			
VUD4 ..	11.830	25.36	10.0 a.m., 2.30, 5.50, 7.15.	HVJ ..	6.190	48.47	9.15.
VUD3 ..	15.290	19.62	10.0 a.m.	<b>LONG- AND MEDIUM-WAVE TRANSMISSIONS</b>			
<b>Iran</b>					Kc/s	Metres	
EQB (Teheran) ..	6.155	48.74	8.30.	<b>Ireland</b>			
<b>Japan</b>				Radio-Eireann ..	565	531	2.40†, 7.45†, 11.0†, 11.5†.
JLG2 (Tokio) ..	9.500	31.57	11.30.	<b>U.S.S.R.</b>			
JZI ..	9.535	31.46	7.0.	Moscow 1 ..	172	1,744	12.0 midt.
JZJ ..	11.800	25.42	7.0.				

It should be noted that the times are **two hours** ahead of GMT, and are p.m. unless otherwise stated. The times of the transmission of news in English in the B.B.C. Short-wave Service are given on the following page.

\* Saturdays only    § Saturdays excepted.    † Sundays only.    ‡ Sundays excepted.

## The World of Wireless—

producers in the U.S., who has given the company all the information required for the cutting of crystals.

## B.B.C. SHORT-WAVE TRANSMISSIONS

THE change in the short wavelength used for the transmissions for the Forces from 42.46 metres (GRS, 7.065 Mc/s) to 48.86 metres (GRW, 6.14 Mc/s) has not made any alterations necessary in the frequencies used for the transmission of news in English in the B.B.C.'s European and World Services. It should, however, be pointed out that the frequency of GRW has recently been slightly adjusted from 6.145 Mc/s to 6.14 Mc/s. For the convenience of readers we repeat the details given in last month's issue:—

0000 ...	49.59*, 41.49*, 30.96*.
0045 ...	31.32, 31.25, 25.53.
0130 ...	49.59*.
0200 } 0245 } 9630 }	31.32, 31.25, 25.53.
0815 ...	31.55, 31.25, 25.53, 19.82, 19.66.
1000 ...	49.59*, 41.49*, 31.55, 30.96*, 25.53, 25.20*, 19.82, 19.66, 19.60.
1300 ...	31.25, 25.53, 19.82, 16.84, 13.97, 13.92.
1500 ...	19.82, 16.84, 13.97, 13.93, 13.92.
1530 ...	49.59*, 41.49*, 25.38*, 25.20*.
1800 ...	31.75, 25.53, 19.82, 16.84, 13.93, 13.92.
2000 ...	31.25, 25.53, 24.92, 19.82, 19.66, 16.84.
2245 ...	31.25, 25.53, 19.82, 19.60.

The times are BST (two hours ahead of GMT). Wavelengths marked with an asterisk are used in the European Service.

## FROM ALL QUARTERS

### Obituary

WE regret to record the death, at the age of 63, of Lord Cadman, D.Sc., F.R.S. He was a man of very wide scientific experience and will be remembered by the wireless fraternity for his vice-chairmanship of the Bridgeman Television Committee.

The death occurred on May 22nd of Mr. Walter C. Barraclough, a pioneer of the wireless industry in the North of England. He represented the industry on the programme advisory committee of 2ZY, the original Manchester station of the B.B.C. He was a keen amateur and operated 5AJ.

### Radio Officers' Bravery

TRIBUTE to the radio officers in the employ of the Marconi International Marine Communication Company was paid by the chairman, Admiral H. W. Grant, C.B., at the forty-first ordinary general meeting of the company. He pointed out that three of them had received the O.B.E., one had been appointed an M.B.E., two had been awarded the D.S.C., and ten had received commendations. In addition three had won the Lloyd's War Medal for bravery at sea. In the King's Birthday Honours four radio officers in the Merchant Navy were appointed Members of the Order of the British Empire.

## B.B.C. Women Operators

THE B.B.C. recently advertised for a number of women operators for the staff of the engineering division. Successful applicants, who should be between 21 and 35 years of age, should "preferably have some knowledge of elementary physics and electricity and possess a keen interest in broadcasting." It is understood they will be given a period of training and will then be posted to a B.B.C. centre, where they will operate recording and reproducing apparatus.

## Monitoring Stations in the States

THE United States Federal Communications Commission recently announced the establishment of "listening posts" to record, translate, transcribe and analyse short-wave broadcasts from foreign countries. These monitoring stations are being set up on the recommendation of the Defence Communications Board.

## I.E.E. Wireless Section Committee

THE Committee of the Wireless Section of the Institution of Electrical Engineers has made the following nominations to fill the vacancies which will occur on the Committee on September 30th, 1941:—Chairman, Mr. H. Bishop, C.B.E., B.Sc. (Eng.), (British Broadcasting Corporation); vice-chairman, Mr. A. H. Mumford, B.Sc. (Eng.), (Post Office Engineering Department); ordinary members of committee, Mr. H. G. Beer (Post Office Engineering Department); Mr. F. P. Best, M.Sc., B.Eng. (Marconi International Marine Communication Co.), Mr. H. G. Hughes, M.Sc. (H.M. Signal School), Prof. Willis Jackson, D.Sc., D.Phil. (Manchester University), Dr. H. A. Thomas, D.Sc. (National Physical Laboratory).

## Minister of Information on Servicing

THE Council of the Scottish Radio Retailers' Association recently announced that the Minister of Information had intimated that he had notified the Ministry of Labour and National Service of his appreciation of the importance of maintaining domestic receivers in operation. The Council contend that this fact demands an adequate complement of engineers for the purpose. Recognition, however, by the Ministry of Labour has not yet been received.

## "Electronic Engineering"

THE monthly journal *Electronics and Television and Short-Wave World*, published by Hulton Press, Ltd., has changed its title to *Electronic Engineering*. Mr. G. Parr, formerly in charge of the Ediswan Radio Technical Service Section, has been appointed Editor.

## Mr. Frank Gill

MR. FRANK GILL, O.B.E., chairman of Standard Telephones and Cables and the International Marine Radio Company, was created a Knight Commander of the Order of St. Michael and St. George in the Birthday Honours. He is a past president of the Institution of Electrical Engineers.

## The Wireless Industry

NORMAN ROSE (ELECTRICAL), LTD., who specialise in replacement parts such as electrolytic condensers, volume controls and transformers, have moved to 80, St. Mary's Road, Ealing, London, W.5.

Mr. A. McVie, General Manager of Kolster Brandes, Ltd., has been appointed a director of that company.

## BOOKS ON WIRELESS

issued in conjunction with "The Wireless World"

	Net Price	By Post
"FOUNDATIONS OF WIRELESS," by A. L. M. Sowerby, M.Sc. Second Edition Revised ...	5/-	5/6
"RADIO LABORATORY HANDBOOK," by M. G. Scroggie, B.Sc., A.M.I.E.E. Second Edition Revised and Enlarged...	10/6	11/1
"WIRELESS SERVICING MANUAL," by W. T. Cocking, A.M.I.E.E. Sixth Edition Revised and Enlarged ...	6/-	6/6
"HANDBOOK OF TECHNICAL INSTRUCTION FOR WIRELESS TELEGRAPHISTS," by H. M. Dowsett, M.I.E.E., F.Inst.P., M.Inst.R.E. Sixth Edition Revised ...	21/-	21/9
"WIRELESS DIRECTION FINDING," by R. Keen, B.Eng. Hons. Sheffield, A.M.I.E.E. Third Edition ...	25/-	25/9
"RADIO DATA CHARTS," by R. T. Beatty, M.A., B.E., D.Sc. Second Edition ...	4/6	4/11
"TELEVISION RECEIVING EQUIPMENT," by W. T. Cocking, A.M.I.E.E. ...	8/6	9/-
"RADIO INTERFERENCE SUPPRESSION," by Gordon W. Ingram, B.Sc. ...	5/-	5/4
"LEARNING MORSE," Seventh Edition ...	6d.	7½d.
"RADIO DESIGNER'S HANDBOOK," Edited by F. Langford Smith, B.Sc., B.E. ...	8/6	9/1
"THE WIRELESS WORLD" GREAT CIRCLE PROJECTION MAP ...	2/-	Post free

Obtainable from Leading Booksellers and Railway Bookstalls or by post (remittance with order) from

ILIFFE & SONS LTD., Dorset House, Stamford Street, London, S.E.1

# Designing Resistances

## Abac for Estimating Eureka Wire Windings

By R. F. BLACKWELL, B.Sc., A.R.C.S. (Murphy Radio, Ltd.)

IN the radio laboratory it is frequently necessary to calculate wire-wound resistances. The usual method is to use the data given in the maker's handbook as the basis of the calculation, adding about 5 per cent. to the length of wire obtained and then measuring the resistance on a Wheatstone Bridge, the length being shortened until the required resistance is obtained. It will, therefore, be seen that the calculation is not required to a very high degree of accuracy and an abac will fulfil the purpose completely.

The abac to be described gives, in three movements of a straight-edge, the length of wire required, the number of turns on a given former, and the length of the winding if only a single layer is used. In order to help in the choice of a suitable gauge of wire the current required for a temperature rise of 100 degrees Centigrade and the number of turns per inch are given.

For the purpose of description, the abac can be split up into three separate

The three scales are drawn logarithmically on three equidistant parallel lines, with the same unit of length for a factor of ten, the L and D scales decreasing downwards and the R scale increasing downwards (Fig. 1).

Suppose a straight-edge to be turned about the 100 mark on the L scale. Then in moving from 100 to 10 on the D scale, it has moved from 1 to 100 on the R scale, i.e. twice the distance, and in opposite directions.

Hence,  $\log R = \log K_1 - 2 \log D$ ,  $K_1$  being a constant to allow for differences in the units.

$$\text{therefore } R = \frac{K_1}{D^2} \dots \dots (1)$$

This shows that, for a constant value of L, R is inversely proportional to  $D^2$ .

Now suppose the straight-edge to be pivoted on the D scale at the 10 mark. Then, in moving from 100 to 10 on the L scale, it has moved also from 100 to 10 on the R scale.

Hence,  $\log R = \log K_2 + \log L$ , therefore  $R = K_3 L \dots \dots (2)$

This shows that R is directly proportional to L for a constant value of D.

Combining (1) and (2), the result is :

$$R = \frac{KL}{D^2}$$

which is the formula (A) required.

Thus if the abac is drawn as described above, the scales will be in the correct relation to one another.

**Number of Turns.**—If T is the length of a single turn on the former to be used, i.e. the length of the perimeter, then the number of turns, N, will be given by:—

$$N = \frac{KL}{T} \dots \dots (B)$$

where K is a constant.

In this case, the scales are parallel, the distance between the L and T scales being twice that between the N and L scales (Fig. 2), all three scales decreasing downwards.

If the unit of length on the T scale is a, then on the N scale it is  $a/2$  and on the L scale  $a/3$ .

By pivoting a straight-edge at 100 on the N scale, it will be seen that as L decreases by a factor of 10, T also does the same,

therefore  $\log T = \log K_1 + \log L$

therefore  $T = K_1 L \dots \dots (3)$

By pivoting about 100 on the L scale, it will be seen that as N decreases

by a factor of 10, T increases by the same factor.

therefore  $\log T = \log K_2 - \log N$

therefore  $T = K_2/N \dots \dots (4)$

Combining (3) and (4), and rearranging,

$$N = \frac{KL}{T}$$

which is the formula (B) required.

As the coil former is usually cylindrical, the length of a single turn, T, is given by  $T = \pi C$ , where C is the diameter of the former. Thus, a scale of diameters can be added to the T scale.

**Length of Winding.**—The length of a single-layer close-wound winding W is given by

$$W = KND \dots \dots (C)$$

where K is a constant.

The distance between the N and W scales is  $1\frac{1}{2}$  times that between the W and D scales, the W scale unit length being  $\frac{2}{3}$  and the N scale  $1\frac{1}{2}$  times that of the D scale (Fig. 3).

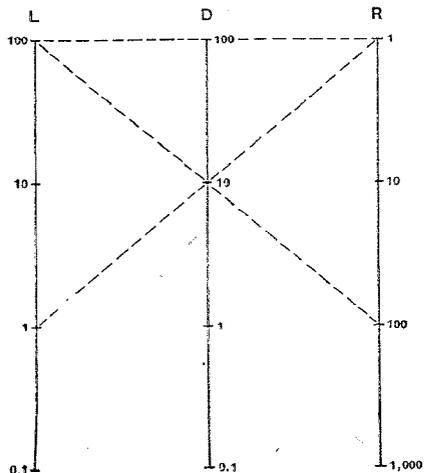


Fig. 1. Key diagram showing how length of wire is ascertained.

parts:—(a) Length of wire required for a given resistance and gauge; (b) Number of turns of this wire on a former of given size; and (c) Length of former required for a single-layer winding.

**Length of Wire.**—If R is the resistance, D the diameter and L the length of the wire, then:—

$$R = \frac{KL}{D^2} \dots \dots (A)$$

where K is a constant.

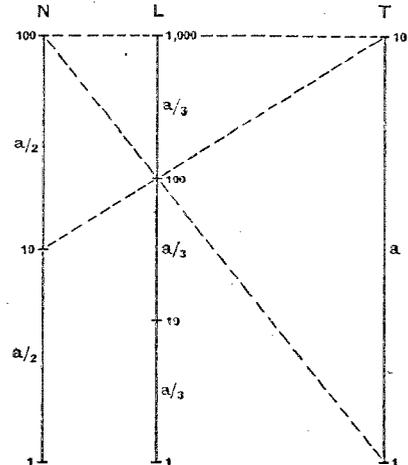


Fig. 2. Estimating number of turns.

As before, it will be seen that

(a)  $\log D = \log K_1 + \log W$ , and

(b)  $\log N = \log K_2 + \log W$ .

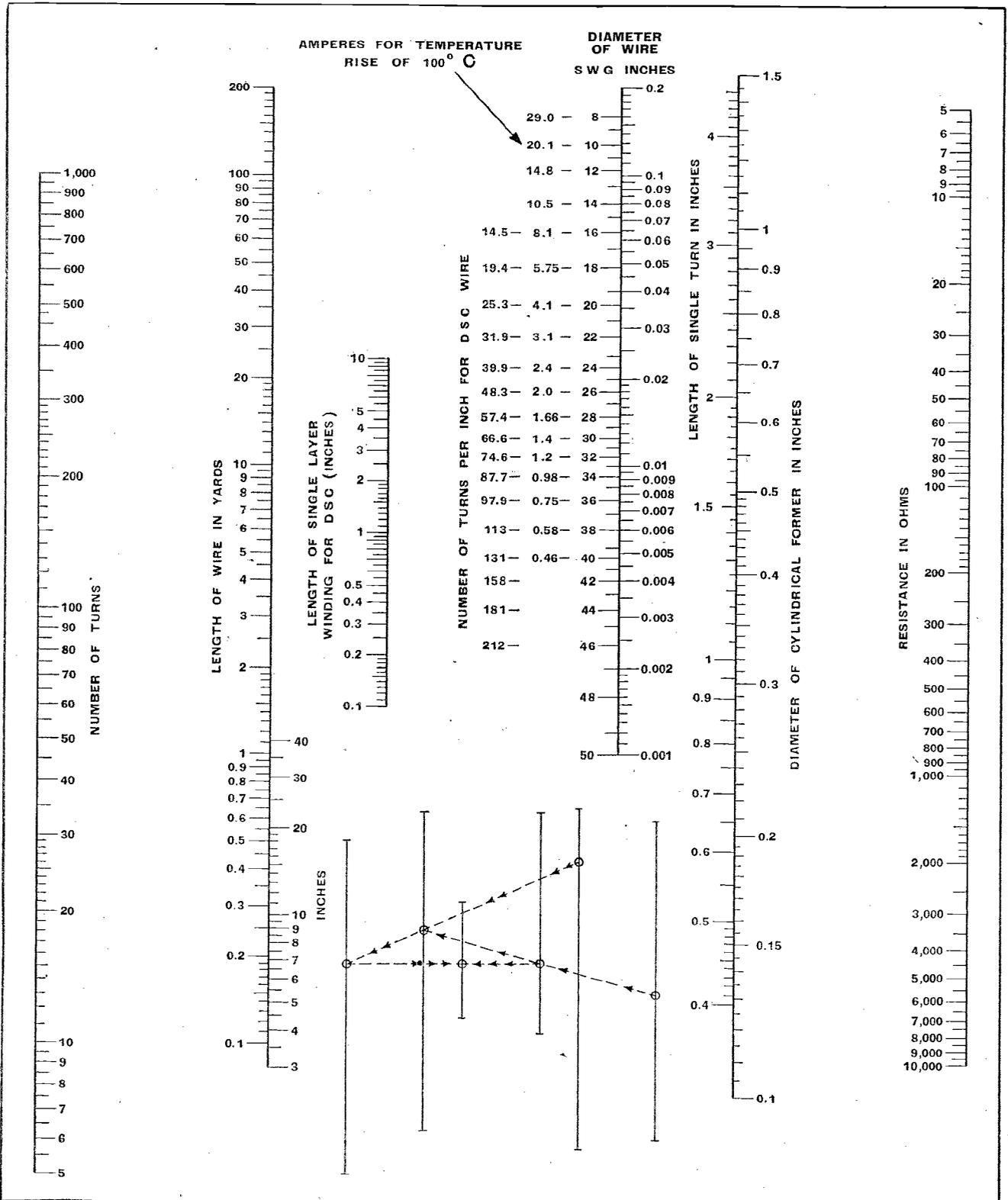
$$\therefore D = K_1 W \dots \dots (5)$$

$$\text{and } N = K_2 W \dots \dots (6)$$

Rearranging (5) and (6),  $W = KND$ , which is formula (C).

**The Complete Abac.**—It will be seen that the first and second abacs can be constructed with a common L scale, the second and third with a common N scale and the third and first with a common D scale, provided

## DESIGNING EUREKA WIRE-WOUND RESISTANCES



Data is obtained in three operations, as shown by the key and explained in the text.

## Designing Resistances—

that the relative distances between the vertical scales are not altered.

A scale of SWG has been added to the D scale and refers to wire with no covering. As this scale is also used

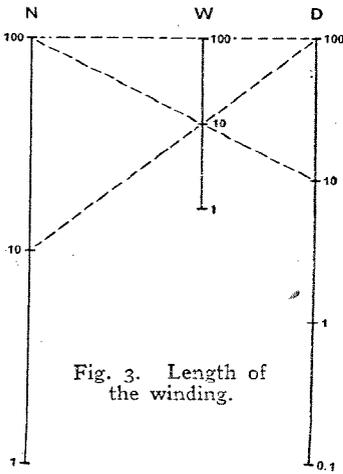


Fig. 3. Length of the winding.

to find the length of winding for DSC wire, the result cannot be very accurate, as in the case of the thicker gauges the covering will be negligible with respect to the wire, but, in the case of the thinner gauges the reverse will be true. The position of the scale was fixed for 24 SWG and may be taken to be sufficiently correct up to about 30 SWG. For gauges above 30, the scale readings should be doubled.

The result will then be within about plus or minus 30 per cent., which is sufficiently accurate, as it is only intended to give a rough idea of the length of former required.

The method of use is explained by the small "key-diagram" within the abac and consists entirely in performing the operations of the three separate abacs.

As an example, suppose a resistance of 100 ohms is required to be wound on a former of diameter 1 inch, the wire to be 30 SWG DSC.

Connecting 100 ohms to 30 SWG gives 18 yds.; connecting 18 yds.

to 1 inch former gives 207 turns; connecting 207 turns to 30 SWG gives 3.0 in.

## Foreign Journals

ALTHOUGH the paper shortage has of necessity had some effect on the number of pages in *The Wireless Engineer*, the Abstracts and References section has not been seriously affected. In the June issue 24 pages are devoted to this section, which is a regular feature of our sister journal. Some of the abstracts from journals published in enemy countries occupy as much as two pages. The length is influenced by the fact that the journals are inaccessible to the average reader, and is not necessarily an indication of their relative importance.

In addition to the Abstracts and References section, the June issue contains a summary of recently accepted wireless patent specifications and articles dealing with the inductance linearised time base, the Pierce piezo-electric oscillator and the Crosley contrast expander. The natural and resonant frequencies of coupled circuits is dealt with editorially.

Published on the first of the month, *The Wireless Engineer* is obtainable to order through newsagents, or direct from our publishers at Dorset House, Stamford Street, London, S.E.1, at 2s. 8d., including postage.

## Book Received

**Experimental Radio Engineering.** By E. T. A. Rapson, M.Sc., A.C.G.I., A.M.I.E.E., assisted by E. G. A. Ackermann. This book describes in detail a number of experiments and methods of measurement suitable for a three or four years' course in radio engineering at a technical college. Component values used in carrying out the tests are given. The experiments described range from the study of simple resonant circuits and the examination of static characteristics of valves to the measurement of the various qualities of a complete radio receiver. A final chapter deals with the use of cathode-ray tubes. Pp. 143; 169 figures. Published by Sir Isaac Pitman and Sons, Ltd., Parker Street, Kingsway, London, W.C.2. Price 8s. 6d. net.

## TECHNICAL INFORMATION

### Suspension of Individual Service

SOON after the outbreak of war *The Wireless World* was compelled to suspend its free service of replies to readers' queries. The technical staff had been seriously depleted by calls from the Services, and it was considered that the energies of the remaining members should be devoted to the production of the journal for the benefit of readers as a whole, rather than to dealing with queries from individuals.

Readers are reminded that this suspension is still in force, and, it is regretted, must remain so for the duration of the war.

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# UNBIASED

## Aladdin and His Ultra-Short-Wave Lamp

By  
FREE GRID

THERE is not a great deal of opportunity these days for theatre-going and such like frivolities, but I was invited the other day by my daughter Kilocyclia to visit an operatic performance by one of those horrible ultra-modern ultra-highbrow and ultra-Bohemian operatic societies to which she belongs. The activities of these wretched societies are almost invariably conducted in glorified cellars and similar subterranean funkholes, and so they are now able to carry on when more worthy institutions have had to close down until Adolf has been permanently earthed.

The play which was presented was written by a member of the dramatic society, and even if I had not been told so I should have guessed it, for of all the boring, meaningless and mealy-mouthing of words I have ever heard, this took the biscuit. The theme was a Chinese one, and in certain respects reminded me strongly of Aladdin, even to the presence of an almost completely emasculated Widow Twankey muttering milk-and-water witticisms which were but a travesty of the robust humour of that good lady.



Fire-fighting technique.

I had, in fact, dozed off when I was awakened by a shrill cry of fire, and found that disaster had occurred in the procession-of-lamps scene where the performers were drearily trailing around the stage each with a Chinese lantern swinging precariously on a bamboo pole and having a guttering candle inside it. Mindful of my A.R.P. fire-watching work, I bounded on to the stage and soon put the blazing girl out with a few hearty strokes of a sandbag, although I got nothing but abuse for my pains from the other performers, as my vigorous sandbagging

had reduced her to unconsciousness, which, as I pointed out, was far better than being burnt alive.

When order was finally restored, I expressed my astonishment that in these days of electricity such a dangerous and old-fashioned illuminant as candles were used for the lanterns. It was, however, rather coldly pointed out to me that dry batteries for electric bulbs were completely unobtainable, and I was sarcastically asked whether I would suggest that the mains be used and long lengths of flex be trailed about the stage. I rejoined rather tartly that since the society prided itself on being ultra-modern and ultra-everything else, it was a pity they had not thought of using ultra-short waves.

In the end it was agreed that I should equip the performers with USW lighting equipment, which I was able to do with very little trouble by installing a micro-power USW transmitter in the wings and fitting each lantern with a simple resonant circuit with an ordinary flash lamp bulb across it. The risk of any radiation outside the building was avoided very simply by lining the walls with wire netting.

## More Trouble for Servicemen

I HAVE often thought it strange what a big part chance has played in the case of so many outstanding scientific discoveries. More often than not, our great scientists when they made the invention by which their name was subsequently rendered famous, were investigating something having no bearing at all on the subject.

Personally speaking, I have in the past often found that inspiration has come to me in the bath when I had neither paper nor pencil handy, with the result that mankind has had to suffer. Even if I had had pencil and paper by my side on these occasions I should not have been in a fit condition to use them, and so nowadays when taking a bath I invariably have



Getting down to it.

a secretary handy—on the other side of the bathroom door, of course.

It was pure chance that enabled me to discover a very mysterious effect which has recently been spoiling my reception of the B.B.C. stations, an effect which I felt quite certain was due to the evil machinations of the enemy, but which no amount of patient research work could run to its lair. The trouble was that whenever I took my portable out into the garden, as I have been doing frequently during these lovely Spring days, reception became lamentably poor, so much so that there obviously seemed to be heavy screening somewhere.

Actually it was Mrs. Free Grid who eventually and literally stumbled on to the cause of the trouble when she got the mower out to tackle the crop of dandelions and thistles which Spring always causes to appear on the lawn. She had scarcely started her labours when the mower came to an abrupt halt, with the result that her own mechanical inductance caused her to pitch right over it and come down very heavily to earth, so heavily in fact that several neighbours took to their shelters in alarm.

When she had been rehoisted, I found that some of the blades of the mower had been very badly damaged by a large shell fragment which had just failed to bury itself beneath the surface. In a moment the solution of the trouble came to me, as I found that the whole lawn and garden was, as the result of the winter activities of the A.A. guns, a veritable old iron depository, which had, of course, been seriously upsetting the frame aerial.

Fortunately, my house really is an all-electric one, and the mower is, therefore, electrically driven, so that I did not find much difficulty in rigging up a powerful solenoid and an extra "grass" box in front of the blades, with the result that I have already been able to send several consignments, carriage forward, to Lord Beaverbrook.

# LETTERS to the EDITOR

The Editor Does Not Necessarily Endorse the  
Opinions of His Correspondents

## Post-war Amateur Transmission

MANY of us now serving in the Forces would like to know how we are going to get on when we come out—especially those of us who held A.A. licences when we joined up. Since then we have been on special wireless courses and training. Our speed is very rarely under 18 w.p.m., and we have theory and practice drummed into us every day of the week until we are able to pass our tests. When we come out I hope the G.P.O. is not going to ask us to pay 5s. for a morse test. Many of us have been in charge of stations ranging from small field portables up to those of several kilowatts. In my own unit there are at least seven ex-amateurs. I suggest cutting out the A.A. licence and putting the beginners on a band of their own, with a maximum of 10 watts after a morse test of 12 w.p.m.

J. E. BOWDEN, EX-2AYQ.

## Should Amateurs Know Morse ?

I CAN only assume that "Jaybee," who wrote in the April issue, has not been active on the 3.5- and 1.7-Mc/s bands, which are not exclusively amateur in Europe and are shared with other services which can almost always claim priority. I know of a number of cases where amateurs have been asked, in a friendly way, to close down for a period to facilitate official traffic.

At 02.25 GMT on November 20th, 1938, after finishing a CW QSO on the 1.7-Mc/s band, I was called by OXB and asked to close down as I was interfering with his telephony service. While I believe that I could have safely ignored this appeal, obviously OXB's coastal traffic was more important than my own, so I closed down. The significant point about this incident is that OXB, while operating a 'phone service, came on CW to ask me to close down, presumably because he thought that he had a better chance of raising me by that method.

I know of at least one case where a Liverpool amateur was asked to close down by Seaforth Radio, though I forget whether GLV used 'phone or CW. Also, 3.5-Mc/s enthusiasts will remember that some time before the war the three Services (who shared that band with us) spent some time

closing down amateur stations to see if they would respond, with, if I remember rightly, quite good results. Needless to say, the Service stations used CW.

From the above it looks as if some knowledge of morse is essential for the amateur operator, and I, personally, am of the opinion that the pre-war rate of 12 w.p.m. cannot be improved upon.

H. WHALLEY, G2HW.  
Darwen, Lancs.

## Transatlantic Frequencies

IN the June *Wireless World* "Dial-list" raises the question as to what is the highest frequency in use in America that is regularly heard in this country. It is interesting, in this connection, to examine the ionosphere data for the Northern Hemisphere with a view to finding out what is the highest frequency that should *theoretically* be regularly received.

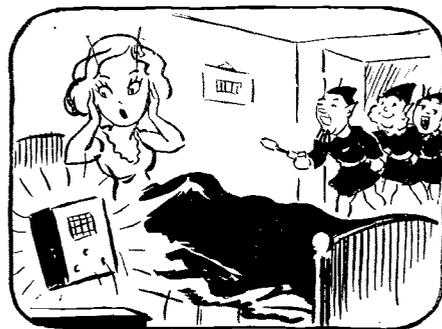
The highest *average* values of critical frequency for the F<sub>2</sub> layer (at Washington) during the last sunspot maximum occurred during the autumn of 1937, when the average critical frequency around noon was as high as 14.2 Mc/s. This would imply that the average maximum usable frequency for waves taking off at small angles to the horizontal would be about 47 Mc/s. On some days the critical frequency was undoubtedly well *above* the average, and this would give rise to maximum usable frequencies perhaps as high as 52 Mc/s.

We must remember, however, that the transmission path from the U.S.A. is of such a length that the wave must make more than one hop in travelling to this country. As noon conditions on this transmission path could not occur at more than one refracting point in the ionosphere, the highest maximum usable frequency for the whole transmission path would be somewhat less than the above.

I think that the highest American frequency heard at all regularly at that time was about 42.6 Mc/s, and we know that the Alexandra Palace sound channel on 41.5 Mc/s was regularly received in the U.S.A. I believe there have been claims to the reception in this country of American signals on 56 Mc/s, though I am not sure of this.

During the spring of this year, the

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## Letters to the Editor—

highest average critical frequency appears to have been in the region of 9 Mc/s, implying a maximum usable frequency of 29 Mc/s for waves taking off at small angles. The highest American frequency regularly heard was, I think, 22 Mc/s, and the previously well-received American broadcasters on 26 Mc/s were seldom heard, so that the practical high limit for the transmission path would appear to have been somewhere between 22 and 26 Mc/s.

The above considerations apply to transmission by way of the regular F<sub>2</sub> layer. Higher frequencies may often be transmitted by way of the Sporadic E, although, owing to the scattered nature of this refracting medium, this type of transmission cannot be regarded as normal. Ionosphere data indicates that the upper limit for reflections from the Sporadic E may sometimes be as high as 15 Mc/s at vertical incidence, implying a maximum usable frequency for obliquely incident waves of about 75 Mc/s. It is very unlikely, however, that waves of such a frequency transmitted by way of Sporadic E would bridge the Atlantic, owing to the improbability of this medium existing at all the points of refraction. Such transmission would, in fact, probably be limited to one hop.

This brings us to the second point raised by your contributor, i.e., what is the smallest skip distance recorded for a 50 Mc/s transmission? As I have mentioned, transmission on this frequency at the sunspot maximum would appear to have been near the high limit for transmission by way of the regular F<sub>2</sub> layer. The wave would therefore have to take off at a very small elevation angle (so as to make a large angle of incidence at the layer), and the skip distance would probably be somewhere between 3,500 km. and 4,000 km., depending on the virtual height. The Sporadic E occurs much lower in the ionosphere, and it appears possible that, with Sporadic E of the nature mentioned above, a wave of frequency 50 Mc/s could return to earth at a distance of about 1,000 km.

T. W. BENNINGTON.

### Microphone Amplifiers for Rescue Parties

ELECTRO-ACOUSTIC devices are playing an important part in the defence of Britain, e.g., sound "spotters" for detecting the approach of enemy aircraft, and another application has occurred to me after some experiences in heavily bombed areas, particularly Plymouth.

Rescue squads working desperately against time to remove people buried under debris often ask everyone nearby to be still and quiet in an effort to detect faint knockings or other sounds from the entrapped victims, which will allow tunnelling to commence at the right place.

A microphone-amplifier-loudspeaker (and/or earphones) battery-operated, portable combination of small dimensions would be of considerable value in locating the position of such trapped persons.

A.R.P. workers and rescue parties with whom I have discussed the idea have approved it, but the best practical design is not easy to settle. One point generally agreed upon is that the apparatus must be compact and simply operated with provision for lowering either the whole equipment or a microphone on strong leads

through a small aperture in the debris. Alternatively, a second microphone at the end of a long armoured probe consisting of, say, a light and strong steel tube, would be of great value in exploring the debris. Two-way communication would be helpful, too.

DONALD W. ALDOUS.

Torquay, Devon.

### Newspapers and the B.B.C.

THE Editor is right. The parts played by the B.B.C. and the Press should be more widely differentiated. The B.B.C. should issue just the facts; the Press should write 'em up into readable journalese round snappy pictures. CYNIC.

P.S.—Does anybody know where Hertz was buried? He should be turning pretty considerably in these days. So ought poor old Caxton.

# RANDOM RADIATIONS

## It Works Anywhere

FROM the American G.E.C. I hear of something that I believe to be quite new in the way of portable receivers. The brief particulars sent to me state that the power source is a secondary battery and that the user can (a) work the set off its own battery, (b) run in from the mains with the battery simultaneously on charge, if desired, (c) change the battery from the mains with the set silent, (d) work the set from a car accumulator. No constructional details are given, but I deduce that a 6-volt accumulator is used, plus a small trickle charger and a vibratory converter. Doesn't it strike you as a most desirable kind of receiver for those who want a portable? I can think of only one snag. If the set is a genuine portable—not one of the kind that can be carried only by a Hercules—the battery must be a small one. With the most efficient vibratory generator the current drain must be considerable. Hence the set won't work for long under its own steam and might be rather a problem if pretty frequent access to electric mains for charging purposes were not possible. However, there are not many parts of this country nowadays without their charging stations; even if the right kind of electric mains weren't available, you could always pull out the battery and have it recharged when necessary. I hope that some of our manufacturers will make a note of the idea with a view to producing something of the kind when

By "DIALLIST"

peace returns. It's the sort of thing that ought to make a wide appeal.



## The Ultra-Shorts

LAST month I asked two questions about the performance of ultra-short-wave transmissions, explaining that I had not laid eyes on my own textbooks and records, or my fingers on the controls of a USW receiver for nearly two years. The first question was: What is the highest frequency used in America which is, or has been, heard at all regularly in this country? To both this and my second question, What is the smallest skip distance on record for a 50-megacycle transmission? a kind correspondent has supplied the answers. I believe that his letter is printed elsewhere in this issue, so that you may read for yourself the interesting facts and figures that he gives. As regards reception in this country of 56-megacycle transmissions from the U.S.A., I have a strong recollection that not a few claims to have performed this feat were established beyond all doubt. Again, I wish I could get at my records. Perhaps some of those who actually heard 56-Mc/s U.S.A. stations in or about 1937 will be able to confirm. It is mighty unlikely that anything of the kind will occur for some years now, except possibly as a freak, for we have left the sunspot maximum a long way be-

## Wireless World

### Random Radiations—

hind us and the F2 layer's critical frequencies won't by all the rules reach the heights they attained then until the next maximum is with us or imminent.

### Valuable Work

The last sunspot cycle from maximum to maximum is the first full one that has occurred since the short waves and the ultra-shorts began to be taken seriously. A vast amount of valuable work has been done. Daily measurements have been made and records kept of the doings of the E and F layers for many years now. These have been correlated not only with the records of solar and magnetic observatories, but also with the records of radio experimenters and observers who have obtained data about radio reception on all the generally used frequencies in almost every part of the world. The work of correlation and of extracting the lessons to be learned is probably still far from complete; but it has gone far enough to enable us to revise many of our ideas about SW and USW transmission. Still more valuable work will doubtless be done between now and the next sunspot maximum, and some, if not all, of the perplexities of the "wavelets" will be perplexities no more. And it's not only the professional astronomers, scientists and radio workers who take part in increasing our knowledge of the behaviour of wireless waves. The amateurs have done outstanding work in the past; they are still doing it, and long may they continue!

### How Data are Obtained

In all of the more important civilised countries there are observatories or departments of observatories specialising in either solar or magnetic measurements. Amongst other things, the solar observatories record the number and size of sunspot groups (the area being usually expressed either as a fraction of the sun's visible surface, or in "square degrees"), the position of the groups, the appearance of solar prominences—great tongues of flaming gases that may leap for hundreds of thousands of miles from the sun's rim—and so on. The magnetic observatories, besides keeping a check on the vagaries of the compass needle, record the incidence, duration and intensity of magnetic disturbances. In addition, the critical heights of the reflecting layers at various frequencies are measured regularly by some observatories, such as Washington. Tokio extends its activities to the re-

coding of radio black-outs. In peacetime an American institution collects and compiles data from all over the world by means of radiotelegrams sent in a special code. The institution is still active, though its activities are now to some extent hampered by war conditions; some of the foreign observatories upon which it relies have dropped out of the running. However, observations are still being made by a network of stations extending all over the U.S.A. from Alaska to the South, and by others in Japan and Australia. Even though the world is at war, the great work of investigation of the laws that govern wireless transmissions goes forward.

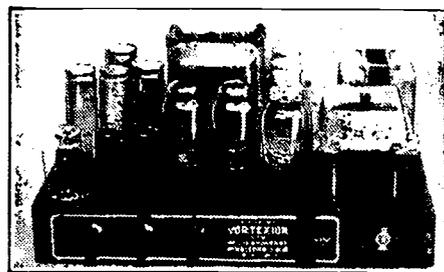
### A Splendid Log

MY best thanks to an old and valued correspondent who, in response to my appeal for information about the reception of medium-wave American stations, has very kindly gone to immense trouble in making detailed extracts from his log and sending them on to me. You'll appreciate how much trouble when I tell you that the extracts form a *daily* record from August 1, 1940, to February 28 this year, with only six days omitted. On these no attempt at reception was made. My correspondent is well placed for transatlantic reception and is a highly skilled old hand at the game; still I was surprised to learn that on none of the 206 nights covered by his log did he fail to hear something from across the Pond. If the North Americans weren't there, the South Americans were, and vice versa. Rather curiously the two best periods—both short—for N.A. reception were in September.

### N.A. and S.A. Nights

As a rule you don't hear the North American and the South American stations well on one and the same night. For this we may be thankful, for if they all came in together in fine voice we shouldn't find many that were intelligible. But there are nights when some South Americans come in strongly, though the D-X bag is mainly from the North and, vice versa, I have heard one or two strongish North American transmissions on what the D-Xer knows as South American nights. A curiosity of last season disclosed by this teeming log is that WBZ (Boston) and XENT (Nueva Laredo, Mexico) were more than once using the same frequency and interfering badly with one another. On one night LRI (Buenos Aires) had adopted the frequency and was giving WBZ a bad time.

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A pair of matched 6L6's with 10 per cent. negative feedback is fitted in the output stage, and the separate HT supplies to the anode and screen have better than 4 per cent. regulation, while a separate rectifier provides bias.

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CHASSIS with valves and plugs ..... £17 10 0

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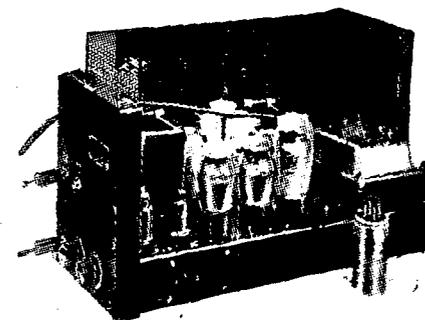
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# RECENT INVENTIONS

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### CRYSTAL BAND-PASS FILTERS

IF a piezo-electric crystal P is cut to a wedge-shaped section, as shown in Fig. 1, it can be made to pass a band of frequencies, instead of responding only to one fundamental frequency. The width of the band depends upon the

Using piezo-electric crystals for variable selectivity.

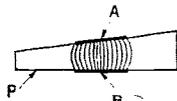


FIG 1

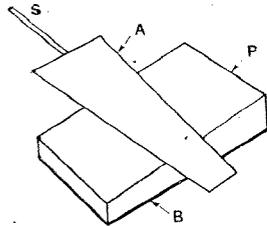


FIG 2

length of the electrodes A, B, each transverse section of the crystal being resonant to a progressively increasing frequency, as indicated by the connecting lines.

According to the invention this property is utilised to provide a band-pass filter of variable selectivity by making the upper electrode A of the shape shown in Fig. 2 and arranging for it to be moved across the upper face of the crystal P, say by operating a shaft S. The device can then be used as a variable element in the coupling between two stages of a wireless receiver, the shaft S being operated by any suitable means to provide automatic selectivity control. Several such units may be used in combination with a ganged control.

The General Electric Co., Ltd., and R. F. Proctor. Application date, 3rd April, 1939. No. 527186.

o o o o

### MINIMISING INTERFERENCE

THE obvious way of reducing the effect of an interfering signal is to sharpen the selectivity of the receiving circuits, though if this remedy is pushed too far the sidebands of the desired signal will be severely cut and the quality of reception falls off. As a refinement, it is possible to increase the selectivity of the bandpass circuits on one side only of the carrier wave, namely, that on which the interfering signal is located, full use then being made of the other sidebands on the opposite side of the signal carrier in order to maintain the quality of reception. Circuits are known in which such selectivity control comes into operation automatically as soon as an interfering signal makes its presence felt on either side of the desired carrier wave, the control being exercised asymmetrically so that it is effective only on the par-

ticular sideband that is being overlapped.

The invention is concerned with the case where interfering signals may occur on each side of the signal carrier wave and where, because one is more severe than the other, an asymmetric adjustment of selectivity becomes necessary in order to eliminate both. It is pointed out that this usually involves a considerable degree of frequency distortion in the desired signal, after it has been freed from interference. The invention accordingly discloses a circuit arrangement which is designed to eliminate disturbances of the kind in question without giving rise to frequency distortion, and in which certain undesirable damping effects are also avoided.

E. P. Rudlim. Application date March 21st, 1939. No. 527292.

o o o o

### DF BY TELEVISION

A ROTATING beam is made to convey a televised picture of its instantaneous position in space, so that the navigator of a distant vessel can read off his bearings relatively to the beacon transmitter.

A frame aerial F is constantly rotated by a motor M at the same speed as a spindle S carrying a scale C marked with

compass points, the scale being simultaneously scanned by a disc D, also driven by the motor M. In this way picture signals representing the scale markings are developed by a photo-electric cell P and are fed to an amplifier A and modulator K, the latter being coupled to a carrier-wave generator O. The same motor M also drives an alternator G which supplies a low-frequency current to a transformer T connected

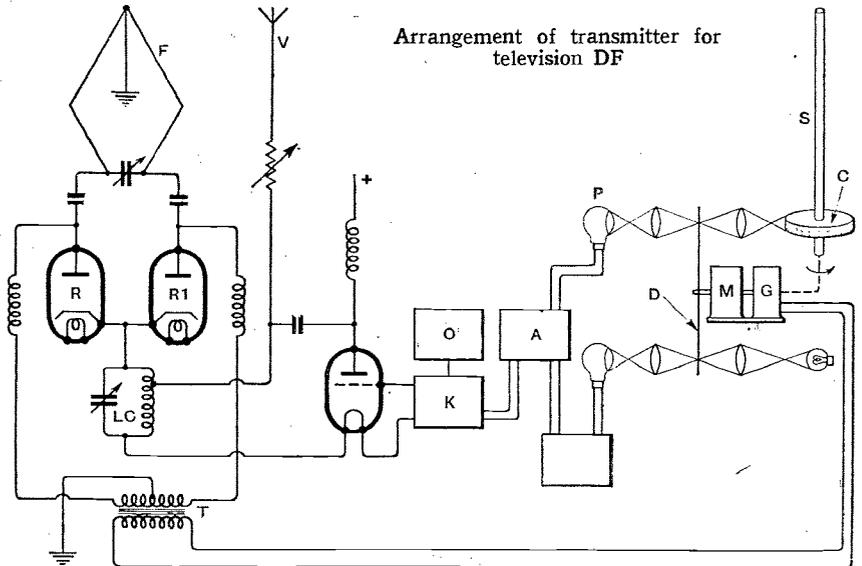
across two diode rectifiers R, R1 which couple the frame aerial F to a tuned oscillator circuit LC. A vertical aerial V is also tapped across the circuit LC, so as to give the combined radiation from the two aeriels a cardioid or heart-shaped characteristic in known fashion. The effect of the AC voltage from the transformer T on the diodes R, R1 periodically "reverses" this cardioid curve at the AC frequency, so that the effective radiation is a double beam with an overlapping part, the whole being swung round the horizon as the frame aerial rotates. At the receiving end two images of the compass scale reading are shown side by side, the correct bearing being indicated when both the images are of equal size.

Marconi's Wireless Telegraph Co., Ltd. and R. J. Kemp. Application date April 19th, 1939. No. 527841.

o o o o

### SHORT-WAVE AERIALS

THE normal radiation pattern of a horizontal dipole aerial is approximately a figure-of-eight for horizontally polarised waves. This directional response is not so suitable, say, for receiving broadcast television programmes, as the arrangement shown in the figure which consists of two "doubled"



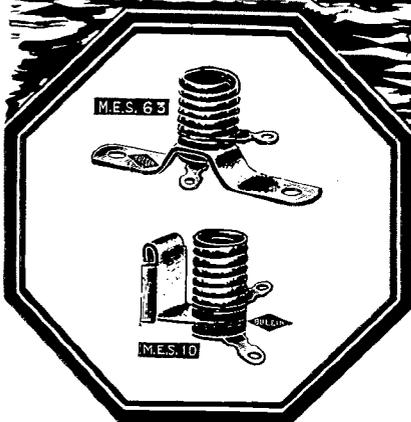
Arrangement of transmitter for television DF

compass points, the scale being simultaneously scanned by a disc D, also driven by the motor M. In this way picture signals representing the scale markings are developed by a photo-electric cell P and are fed to an amplifier A and modulator K, the latter being coupled to a carrier-wave generator O. The same motor M also drives an alternator G which supplies a low-frequency current to a transformer T connected

quarter-wave limbs A, A1 and B, B1, set at an angle of 90° to each other and connected directly to a two-wire transmission line L.

The response of such an aerial is substantially circular, i.e., non-directional, in the horizontal plane. The wires A1 and B1 may be made thicker than the other wires A, B in order to match their impedance better to the line. The distance between the wires A and A1, or

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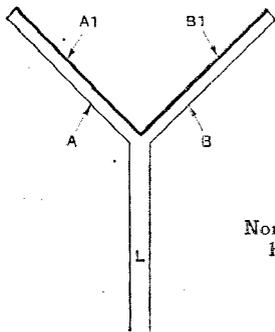
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between B and B1, should be a very small fraction of the working wavelength. The two outer ends of each pair of wires are connected together, so that although the currents flowing through them are in opposite directions along the wires (owing to a phase reversal at the closed ends) the currents flow in the same direction in space. In other words, the radiation



Non-directional  
horizontal  
dipole.

effect is the same as if each pair of double wires were replaced by a single wire.

Marconi's Wireless Telegraph Co., Ltd. (assignees of P. S. Carter). Convention date (U.S.A.), 16th April, 1938. No. 527926.

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FREQUENCY-MODULATED SIGNALS

WHEN signals are transmitted by varying the frequency, as distinct from the amplitude, of the carrier-wave, any increase in percentage modulation involves a corresponding widening of the frequency band occupied by the signals, and this, in turn, increases the difficulty of cutting-out interference, particularly that of the "impulsive" type. The invention is concerned with means for overcoming the difficulty.

With this object in view, the incoming signals are first passed through a selective network having the characteristic of a band-pass filter, and are then rectified. The network is given a transmission range just wide enough to pass the essential sidebands required, and in order to maintain the same admittance as the frequency shifts up and down, the band-pass characteristic of the network can be automatically controlled by the strength of the rectified signals.

For instance, the incoming signals are combined with locally generated waves in phase quadrature, and any out-of-step component, arising either from lack of agreement in frequency or phase, is applied to vary the effective reactance of an iron-cored inductance forming part of the selective network.

Standard Telephones and Cables, Ltd. (assignees of H. Nyquist). Convention date (U.S.A.), 21st May, 1938. No. 528152.

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**COMMUNICATION** Set, also Tuner or coils, etc., for S.W. superhet.—Dunn, Woodside, Loftus, Yorks. [9592]

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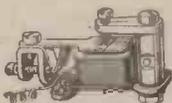
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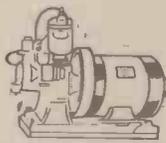
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67/6

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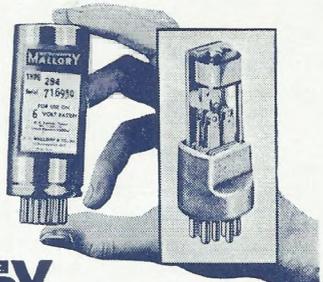
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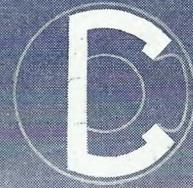
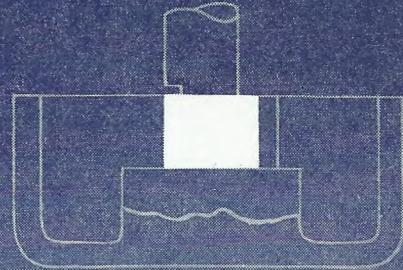
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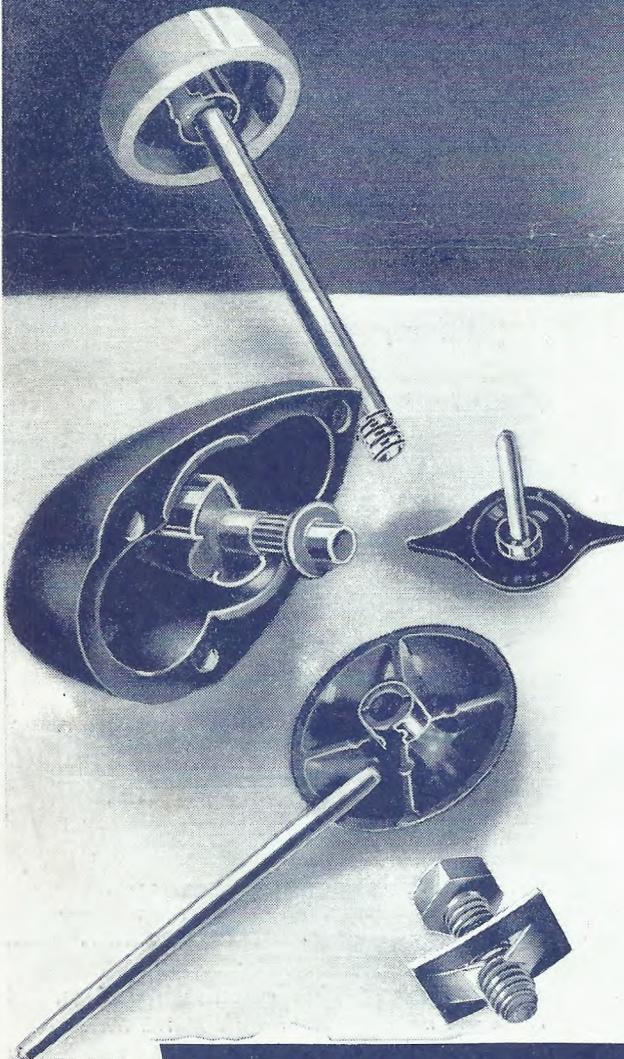
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